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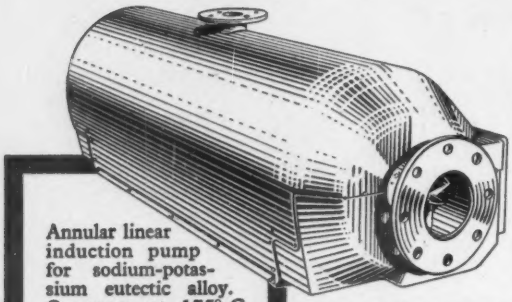

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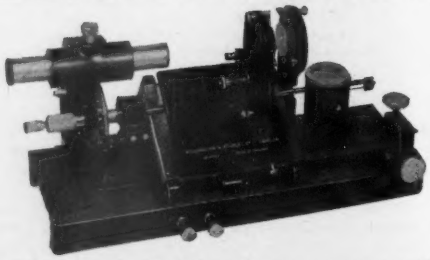

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# TECHNICAL EDUCATION AND SOCIAL CHANGE

IN his Hinchley Memorial Lecture last autumn on "An Education for Our Times", Dr. R. P. Linstead argued that any good system of education would give a good product out of good material, against a good social background; and by a good system of education he meant one starting in breadth and proceeding in depth in the honest study of genuine academic subjects. Dr. Linstead pointed out that in any system of higher education there would be gaps and shortcomings in regions outside the specialist subjects, and these gaps would be most noticeable where the talent is thin or the cultural and social background insecure. This is, he observed, one aspect of the general problem of the incapacity of man to keep up with the growth of knowledge and to adapt himself to the complexity of the world.

The universities in Britain have been increasingly aware of the close relation between their work and the social and cultural background of their students. The widening strata of society from which their students are drawn involve changes in the assumptions in their teaching and in the demand made on some of their institutions, for example, the university library, just as social change may involve changes in the content and the extent of their faculties. Not the least merit of Dr. Linstead's lecture was the way in which he showed how easy it is, without foresight, for such changes or new demands to place impossible burdens upon the universities, and to involve expenditure out of all proportion to the return to the community.

If, however, the provision of a broad general education has forced increasing attention to the bearing of social change on education—at least so far as the universities are concerned—the relation between technical education and social change has received comparatively little attention. Dr. S. F. Cotgrove's recent study of that subject* is therefore to be warmly welcomed, in that it directs attention to factors of supreme importance in considering the provision of trained man-power. Moreover, this fresh approach is in itself suggestive of new ideas; and although in the main Dr. Cotgrove is essentially factual, here and there he hints quite plainly if less forcefully than Sir Hugh Beaver did recently, that in education, for all our protestations, there is in Great Britain neither a national policy nor the national organization to secure one.

To read the recent report of the Minister of Education on "Education in 1957"†, bearing in mind that Scotland is excluded and that the chapter on university awards is now limited to arts subjects, since the Department of Scientific and Industrial Research took over the responsibility for science awards, is to realize how fully justified are Sir Hugh's strictures and the quieter comments of Dr. Cotgrove. What stands out from all three documents is the importance of dealing with education as a whole, and the danger and waste of sectionalism, whether geographical, administrative or disciplinary. There is at present no official means of securing a comprehensive view of the whole field or, short of Cabinet level, for securing concerted action if needed.

Sir Hugh Beaver devoted almost half his lecture on "Science and the State", given before the Institution of Chemical Engineers, to the question of education, showing how the production of an adequate supply of scientists and technologists depends on an effective national policy for education. In the absence of such a policy and the means to concert and to execute one, our hope of increasing the supply of scientists and technologists depends upon the agreement of a large number of departments, authorities, schools, colleges and other bodies that such an increase is necessary (and Sir Hugh might have added that many such bodies are dominated by people with no first-hand appreciation of science or technology); the immediate provision of the finance; and an adequacy of teachers. Sir Hugh Beaver emphasized the critical importance of the supply of teachers, but also referred to the inadequate equipment for science teaching of many schools, and finally stressed that the Minister of Education has neither the responsibility for concerting a policy to produce the technologists and scientists required, nor the necessary scientific advice.

That may be true, but the value of the Ministry of Education's report should not be under-estimated. It shows, very clearly, trends of which due account has to be taken even when we seek elsewhere the means for concerted policy and action. More boys and girls are now staying at school beyond the age of fifteen, and they are staying longer. Moreover, a graph given in the report indicates that, in consequence of the rise in the birth-rate during the past few years, the Ministry of Education is now expecting in ten years time a peak in the school population almost as high as that expected for 1961. A situation originally expected to be temporary may thus prove much more nearly permanent and require more permanent measures of treatment.

On top of this, in spite of record progress in school building, including a number of projects specifically to provide additional science accommodation, and a slight improvement in the staffing position in the primary schools, the staffing position in the secondary schools continued to deteriorate. With increasing recruitment and a record number of teachers in the maintained schools, the effect was only marginal, and the situation remains particularly critical as regards teachers of mathematics and science. The number of such teachers increased, nearly 400 more students concentrated on these subjects in their final year in college, and more than twice as many trained

* Technical Education and Social Change. By Dr. Stephen F. Cotgrove. (Studies in Society.) Pp. 220. (London: George Allen and Unwin, Ltd., 1958.) 25s. net.

† Education in 1957: Being the Report of the Ministry of Education and the Statistics of Public Education for England and Wales. Pp. v+198. (Cmnd. 454.) (London: H.M. Stationery Office, 1958.) 9s. net.

teachers attended the special supplementary courses; but the result was merely to prevent any further deterioration in the relevant staffing standards. A recent debate in the House of Commons on the possible deferment from National Service of third-class honours graduates in mathematics in order to enable them to take up teaching posts merely stressed the shortage of such graduates and the keen competition between teaching and Service training rather than held out hope of any relief from this direction.

Dr. Cotgrove is concerned with technical education rather than with education as a whole; but his survey brings out the dependence of technical education upon what is done in the schools. He provides ample evidence in support of Mr. J. J. B. Dempster's contention, in writing on the secondary modern school in a symposium of articles on the "Educational Framework of an Industrial Society" in *Research*, that if industry is to have the skilled personnel it needs and the secondary schools are to come into their own, a great deal depends upon the skill with which appropriate stimuli are sought and applied, and upon the pattern within which teachers in the secondary modern schools are called upon to work. This point seems to elude Mr. John Wellens in commenting on the series of articles, although he recognizes that secondary modern schools should, and were intended to, provide for the special needs of their pupils and that the secondary technical schools cannot make their full contribution to the supply of technologists unless they receive their proper quota of good students. Moreover, emphasizing that the correct preparation for a study of advanced technology is a good grounding in science and mathematics, Mr. Wellens points out that it is the grammar and public schools that have offered the best preparation for the study of technology, and accordingly the more adequate the secondary technical school becomes in training potential technologists, the nearer it will approach the grammar school.

That of itself should suffice to give pause to some of the attacks on the grammar school which are being made in the name of political dogma, and there is more to that end in Dr. Cotgrove's study. Two of his most valuable chapters are those in which he examines the recruitment of students and in particular the influence of secondary education on the recruitment of students to the technical colleges. Earlier chapters trace the stagnation in technical education in Britain before the 1930's—and even down to 1945—to the indifference and even apathy of industry. During the war years and from 1945 onwards, the changing attitude of industry to research and the increasing application of science to production have resulted in an increased demand for scientific man-power, which has been accompanied by a substantial increase in the attendance of students, both full-time and part-time, at courses in science and technology at the technical colleges and universities. Then Dr. Cotgrove seeks to examine the mechanisms by which the needs of industry for scientists and technologists are translated into the decisions of students to attend the appropriate courses, and to analyse the factors determining the recruitment of students to the technical colleges.

Dr. Cotgrove's survey indicates that, although the main motive in attending technical colleges is the expectation of occupational reward, occupation is the main factor determining attendance. The failure to attract manual workers is attributed to the small rewards in manual occupations for qualifications achieved, and to the fact that most students attend classes to get on in their jobs rather than to change their occupations. Nevertheless, social factors such as social origins can reduce considerably the potential supply of students in science and technology, though among part-time students this appears indirectly in the influence of social origins on entry to occupations and the association between occupation and part-time attendance. The social factors appear most marked in Dr. Cotgrove's survey of the polytechnics; but they also appear in the recruitment to various courses within the technical colleges.

This influence of social class was emphasized three years ago in the report on early school-leaving, as was the wastage through the failure to complete courses for which students have entered. Dr. Cotgrove suggests that attendance might be increased and wastage reduced by greater encouragement and assistance from employers, especially in the form of giving time off for the older students. In this connexion it may be noted that the report of the Ministry of Education records increases of 9 per cent in the number of young employees who attended part-time day release courses in working hours and of 13 per cent in the number of students attending full-time (including sandwich) courses. Sandwich courses now number 203 compared with about 100 when the White Paper on technical education was issued.

Dr. Cotgrove also brings out a close association between secondary education and further education. The grammar school 'leaver' is orientated both towards the universities and towards university courses in the technical colleges, and recruitment to the technical colleges and to courses in science and technology appears to have been hindered by the persistence of the educational and social values of the nineteenth century mediated by the grammar schools. Like the Advisory Council for Scientific Policy in its report for 1951–52, Dr. Cotgrove comments that the study of arts has enjoyed a higher prestige than science, while the superior prestige of science compared with technology has decreased still further the attraction of technical college courses to the grammar school leaver. This is due in part to the pressure by parents for courses leading to 'black-coated occupations' in commerce, finance and the professions; and the recent decline in the proportion of students which the technical colleges draw from the grammar schools and the secondary modern schools has been accompanied by a decline in the proportion of university and other advanced work in the colleges.

Pursuing this inquiry further, Dr. Cotgrove points out that, while the technical colleges contribute substantially to the supply of graduates in science and

technology, only to a slight extent have the technical colleges acted in the post-war years as an overflow for the universities; at the time of the inquiry in 1955, not more than 20 per cent of the students in the sample were attending a technical college because they had been unable to secure a place at a university. Most had not even applied for such a place. Nevertheless, about a third of the full-time and one-half of the part-time students taking a national certificate course covered by the survey seem to prefer a university degree on the grounds of its prestige and greater educational and occupational value.

Dr. Cotgrove emphasizes the need to interpret this evidence with caution; but he is manifestly right in suggesting both that further inquiry is needed to show how far the pursuit of existing paper qualifications is meeting the educational needs of industry, and that more attention should be paid to the intermediate and technician level, which tends to be dominated by the training required for professional qualifications. The conduct of examinations is only one of the functions of a professional body; and although it is one way in which a professional association may serve social needs, it is one in which self-interest may easily lead to distortion and a tendency to safeguard sectional and professional interests rather than to serve public needs. There can be no question as to the public spirit which animates the educational policy of some professional bodies, but Dr. Cotgrove's survey also suggests some doubts as to whether in establishing a National Council for Technological Awards and the Diploma in Technology regard was being had, not so much to the needs of the students or of industry as to the supposed interests of the technical colleges themselves. Dr. Cotgrove makes no such comment, but his factual survey of what passes for policy in technical education relates very clearly the major problems to the conflicts of interest involved, and shows the way in which the original and primary functions of the technical colleges have been overlooked.

Those functions of training craftsmen and technicians in the principles underlying their trade can be met appropriately within the framework of local government administration. It is when this work is combined with that of training technologists that the growth of advanced courses requires concentration in selected areas and the recruitment of students from a wider area, with consequent problems of finance and arrangements outside the local authority area. The questions of prestige and of autonomy which result are liable to be debated subjectively rather than objectively, and such controversies have hampered the development of the technical colleges.

The value of Dr. Cotgrove's book does not lie in any positive contribution to the resolution of such controversies, but rather in indicating the factors to which weight must be given if our efforts to expand the supply of scientists and technologists, technicians and craftsmen are to succeed. Most technical colleges will continue their established role of concentrating on the training of technicians and craftsmen, though perhaps less exclusively on a part-time basis than Dr. Cotgrove implies; but the extent to which others concentrate on the training of technologists should be determined by considerations of man-power needs and resources rather than local or sectional prejudices or ambitions.

Further, more attention should be given to the influence of the social structure and to the educational system of Britain as a whole. Perhaps the outstanding lesson of the survey is that the system of further education must be conceived in relation to the structure of society if the demands for trained man-power are to be met. This involves some radical re-thinking of the relations between the various forms of secondary and further education, and equally a readiness to consider the impact of change on the various elements in the educational system. The apprenticeship system is scarcely mentioned in this study, but obviously has an important bearing, quantitative and qualitative, on the development of technical education. It is not the only point at which entrenched interests and the dead hand of tradition hinder adjustment of the educational system to changing needs of society.

If technical education is to meet the needs of Britain for trained man-power, there is no place for preconceived ideas. Dr. Cotgrove leaves no loophole for believing that any substantial increase in the output from the technical colleges is likely unless positive steps are taken to decrease the factors hindering recruitment. The White Paper on technical education proposed no such changes, and accordingly Dr. Cotgrove believes that any expansion is likely to result from the slow evolution of the system and the increase in the size of the age-groups from which students will be recruited during the next decade. Nor does he believe that the currently expressed needs of industry should dominate the nature of any educational re-organization. This, he urges, and rightly, should depend on much more detailed knowledge of the structure and functioning of the educational system and of the social forces which shape it. There is sound reason, while such knowledge is being sought, for avoiding fundamental change, and care should be taken to create no fresh obstacles to whatever changes or developments may appear necessary.

Such knowledge, however, and especially of the social consequences which are likely to result from educational policy, for example, the effect on social and industrial mobility, should be sought as a matter of urgency. When it is available, however, imaginative and constructive thinking will be no less imperative. To translate the results of such thought and knowledge into action will be a task demanding the co-operation of all concerned to see Britain take her full place in this age of technology; nor is it too early for professional associations as well as educational institutions to seek to promote such co-operation and to remove the misunderstandings and prejudices which are probably the greatest hazards to the formulation and execution of an adequate and effective policy of technical and technological education.

# MOLLUSCAN DEVELOPMENT

## Morphogenesis

The Analysis of Molluscan Development. By Prof. Chr. P. Raven. (International Series of Monographs on Pure and Applied Biology. Zoology Division, Vol. 2.) Pp. xii+311+12 plates. (London and New York: Pergamon Press, 1958.) 70*s*. net.

MODERN developments in experimental embryology may, as Prof. C. P. Raven notes in his introduction to this book, be reviewed in one of two ways. Certain problems may be concentrated on while drawing examples widely from the animal kingdom, or attention may be restricted to a single group, so permitting a survey of the normal course of development as the logical background to the causal analysis which is the aim of experimental studies. Prof. Raven has here chosen the latter course, dealing, as he is so highly qualified to do, with the Mollusca.

Indeed, this phylum offers an almost embarrassing wealth of material for description and analysis. Of its numerous marine representatives, some have larval development, but this may be abbreviated in many ways leading to direct development and even, in the Cephalopoda, to meroblastic discoidal cleavage. The freshwater Gastropoda and Lamellibranchia and the terrestrial Gastropoda exhibit other patterns of development including parasitic glochidia larvæ, ovo-viviparity and special adaptations in connexion with land life. They also present advantages to the investigator which Prof. Raven has fully utilized in his numerous studies on *Limnaea stagnalis*.

The book starts with an account of oogenesis, particularly valuable for its account of cytochemistry, followed by chapters on maturation and fertilization and on cleavage. Descriptive sections, dealing with structure in all its aspects, are followed by accounts, inevitably shorter, of work on causal analysis. The 'outfit' of the embryo is shown to consist of (1) its genotypical constitution, (2) an assortment of substances in the egg cytoplasm, and (3) a cortical field. The latter is considered not only to have a polar structure but also to be organized in dorsoventral and transverse directions.

The same course is followed in dealing with gastrulation and with embryogenesis, with the important distinction made between 'chemo-differentiation' in the embryo and the later 'chemical differentiation' which accompanies histological differentiation. The two, as the author emphasizes, represent opposite trends, one "functioning elements containing a great amount of fuel" and the other "formative cells, in which anabolism preponderates, leading to a synthesis of living protoplasm. . . ." It is interesting to note how, in the course of modern experimental attack, the old idea of mosaic development in the molluscan egg has been destroyed.

Criticisms are relatively minor. Some order might have been imposed on nomenclature when dealing with the excretory organs: larval kidneys include protonephridia, and these, on the evidence of different authors, are said to arise from either ectoderm or mesoderm. No reference is made to the work of Goodrich. The chapter on organogenesis is not altogether satisfactory. There are too few figures, making the unaided verbal descriptions most difficult to follow, for example, in the account of gill formation. There is also some apparent lack of knowledge of adult structure. "Inner and outer gill", meaning the inner and outer demibranchs of the bivalve ctenidium, is not satisfactory; supporting rods are always present within ctenidial filaments; the shell of a bivalve is a single structure with the ligament formed in the same manner as the valves. It does not appear to be realized that there is a fundamental difference between the asymmetry of the kidneys in the Archæogastropoda and in the remaining Gastropoda. There are also other matters which might suitably have been checked by a malacologist.

But it would not do to end on a note of criticism when dealing with a book for which many, including this reviewer, will long be grateful. Not only does it provide an admirable summary of the present state of knowledge in a difficult but most active field of research; it should be the means of stimulating further research.

C. M. Yonge

# HORMONES

## Biochemical Contributions to Endocrinology

Experiments in Hormonal Research. By Sir Charles Dodds. (Stanford Studies in the Medical Sciences, No. 8. The Lane Medical Lectures, 1956.) Pp. viii+76. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 18*s*. net.

IN this volume, which is based upon five Lane Medical Lectures delivered at Stanford University in 1956, Sir Charles Dodds recounts some of the biochemical research work in relation to endocrinology at the Courtauld Institute, Middlesex Hospital. Following a description of early work on insulin and posterior pituitary lobe factors, which is now only of historical interest, the author gives a fascinating account of the difficulties and uncertainties which beset his colleagues and himself in their search for synthetic compounds with œstrogenic activity. Isolation from urine of five different compounds with œstrogenic properties indicated clearly that, in this field at least, the contemporary belief that hormone specificity and structure were closely related was untenable. Such was the simple starting point of this inquiry, and rarely has persistent effort yielded such abundant reward. In stilbœstrol, hexœstrol and dienœstrol the target of cheap, highly active, oral, synthetic œstrogens was achieved, but perhaps the most significant outcome of this work has been the subsequent application of these powerful drugs. Apart from their use in menstrual disorders and weaning, Huggins was able to show that they had useful and possibly unique application in the treatment of carcinoma of the prostate and breast.

The use of synthetic œstrogens in cicuration to improve the quality of chicken and heifer meat has already great economic importance, but is not without potential danger to the animals, to those who handle the treated fodder and to the consumer of the meat. In the future, these compounds, or their derivatives, may find useful application in the control of lipid metabolism in atherosclerosis and allied conditions. It is well known that arterial degeneration is rare in women during active sex life and that the incidence of cardio-vascular disease in men and post-menopausal women with an associated disturbance of lipid metabolism is much higher. There is already some evidence that the abnormal plasma lipid pattern can be successfully treated by œstrogen therapy.

In bringing the brief story of the Courtauld Institute up to date, Sir Charles gives a concise account of the historical background which led to the discovery of aldosterone by Dr. Tait and his wife. Although at some pains to point out the advantages which may follow the association of workers of different disciplines, the author does not comment on the uniqueness of this combination of a radiation physicist and a biologist which resolved the difficulties of the amorphous fraction which had defeated chemists for a quarter of a century. The establishment of the constitution of aldosterone and its subsequent synthesis may have solved the chemical problems, but the important questions of physiological function and clinical use remain unanswered. That aldosterone influences the electrolyte balance is beyond doubt, but whether it does so primarily by action on sodium, potassium and chloride ion excretion in the renal tubules or indirectly by controlling the extra-cellular fluid volume by modification of the permeability of cell membranes is uncertain. Unlike other steroids synthesized in the adrenal cortex, the secretion of aldosterone does not seem to be under pituitary control. A. E. KELLIE

## FOSSIL VERTEBRATES

### Studies on Fossil Vertebrates

Essays presented to David Meredith Seares Watson. Edited by Prof. T. Stanley Westoll. Pp. xii+263. (London: The Athlone Press, University of London, 1958.) Distributed by Constable and Co., Ltd., London. 35*s*. net.

THIS collection of essays deals with a variety of problems of prime interest to vertebrate palæontologists, some relating to the evolutionary history and comparative anatomy of extinct animals, others to the environmental conditions in which these animals lived, and the evidence offered in this respect by the fossiliferous rocks. In all these fields Prof. D. M. S. Watson has made lasting contributions, and it is highly proper, therefore, that the volume now published in his honour, should have this broad coverage.

Among the articles dealing with modern aspects of evolutionary theory, those entitled "Prophetic Fossils" and "Time and Evolution" are worthy of special mention. In the first, Sir Gavin de Beer and W. E. Swinton state the case, with many examples, of paedomorphosis versus recapitulation in the evolution of animals. In the second, J. Brough makes some critical and, as it seems, well-founded comments on the dynamics of evolution as interpreted by the neo-Darwinian school. Taking as an example the history of Actinopterygian fishes during Permo-Triassic times, Brough emphasizes that the transition from the Palæoniscoid to the Sub-Holostean, and afterwards the Holostean stage, which quite obviously took place independently within several different lines, can scarcely be attributed to conditions of small populations in connexion with environmental instability. In this case, as also with regard to the phyletic development of the jaw-apparatus in various mammal-like reptiles, the explanation rather seems to be that the evolution was non-adaptive, that it was influenced above all by variations in the mutation-rate, and that the mutations were, at times, not wholly random, but in some way directional. In such large-scale evolutionary outbursts where new orders, classes or phyla emerged, the causative factor was, so Brough maintains, probably an extremely high mutation-rate. Natural selection, on the other hand, may, in Brough's opinion, have been active as a guiding force in evolution, but only on a lower taxonomical level, for example, for the rise of new species, genera and to a large extent even families. Reviewing the phyletic history of animals from the early Cambrian onwards, Brough, in conclusion, tends to regard evolution as a decelerating process, in which large-scale surges all belong to the past, and which goes on at an ever-decreasing speed until, at some future date, it may cease altogether.

Three other articles in the volume have been written with the intention of summarizing and critically analysing the occurrences of fossil vertebrates in certain geological time-intervals or in certain specific areas. Valuable contributions of this kind are given by two American palæontologists: E. H. Colbert, who, in "The Beginning of the Age of Dinosaurs", presents a broad outline of the evolution of amphibians and reptiles during the critical Triassic period, and A. S. Romer, who, in a highly competent manner, deals with the Texas Permian Redbeds and their vertebrate fauna. E. S. Hills has contributed a brief review of Australian fossil vertebrates which, in condensed form, yields much up-to-date information on the rich finds, in that part of the world, of fishes and tetrapods in strata ranging from the Middle Devonian to the Late Tertiary.

The habitat of fossil lower vertebrates is the subject of two articles, "The Geological Environment of Fossil Fishes", by D. H. Rayner, and "Original Environment of the Craniates", by E. I. White. Miss Rayner has set herself the task of briefly evaluating to what extent such evidence as state of preservation, lithology of enclosing rocks, etc., may reflect the original environment of fossil fishes, giving, in this connexion, a rather detailed account of various fish-faunas from the British Jurassic. E. I. White, on the other hand, has chosen the more limited but highly controversial problem of fresh versus salt water as the habitat of the early vertebrates. After a careful consideration of the evidence, zoological and geological, White concludes that the earliest Craniates were wholly marine, and that the Ostracoderms lived off shore or in estuaries during pre-Devonian times. White successfully disposes of some of the irrelevant or untenable argumentation by which this problem has often been obscured. The frequently cited circumstance, for example, that in the early Devonian the Ostracoderms and fishes occur predominantly in continental sandstones, clearly proves nothing at all concerning the original habitat of the earliest vertebrates; and the view that the Ordovician and Silurian vertebrates belonged to inland waters, and that their detached exoskeletal plates and scales were washed out after death into the sea by rivers, is entirely unsupported by the facts as we know them. There may still be some diversity of opinion on certain of the aspects of early vertebrate history touched upon by White (for example, the successive phases in the phyletic development of the exoskeleton), but this by no means lessens the validity of his conclusions referred to above.

Finally, three articles deal with problems of palæoichthyology. F. R. Parrington and A. Heintz both discuss the anatomy and mode of life of the Anaspids, and in "The Lateral Fin-fold Theory and the Pectoral Fins of Ostracoderms and Early Fishes" T. S. Westoll, the editor of the volume, pursues an

important problem of comparative anatomy. Interesting in many ways as they certainly are for specialists, none of these articles can be reviewed in detail here. It may be mentioned, however, that whereas Heintz in his description of *Birkenia* rejects the view that the Anaspids have a suctorial mouth, Parrington, who mostly considers *Lasanius*, strongly favours the opposite view. According to the latter, the Anaspids may, in their mode of feeding, have been intermediary to some extent between the Cephalaspids on one hand, and the modern lampreys on the other.

The volume of essays presented to Prof. Watson makes excellent and stimulating reading throughout. Its highly varied contents, to which no full justice can be done in a short review, should be of considerable interest to anyone working with vertebrate phylogeny.

TOR ØRVIG

## BIOLOGICAL TESTING OF INSECTICIDES IN THE LABORATORY

### A Critical Review of the Techniques for Testing Insecticides

By Dr. J. R. Busvine. Pp. ix+208. (London: Commonwealth Institute of Entomology, 1957.) 30*s*.

IN the past ten or so years a number of rather similar books have appeared, each of them about the properties, uses and modes of action of insecticides. Dr. Busvine's book is the first to be entirely devoted to methods of testing insecticides; he is to be respected for his courage in tackling a subject with so many specialized subdivisions.

The book does not deal with methods for field tests, nor with chemical tests, but covers all types of laboratory biological tests. It is a review of a large subject, not just a collection of descriptions; it does not list all the methods that have been used for each type of test; and it does not give full details of more than a few. Dr. Busvine has concentrated rather on the principles and theories involved in tests, and on giving suitable guidance.

One of the praiseworthy aims of the book is to encourage greater simplicity and standardization of method. The subject is now well past its pioneering stage, and the methods used have been increasing in diversity and number. As the author says, research workers are "doggedly individualistic"; this has often made it difficult or even impossible to make comparisons among results obtained in different laboratories. There are enough uncontrollable sources of variation in any one type of test without individual workers adding variants of their own.

After three general chapters on principles, and on handling and standardization of insects, the author deals with each type of test, chapter by chapter.

However, there are quite a number of errors in detail, which give the impression that the book has been hurriedly prepared. In matters of theory and of interpretation of results, there are some more serious errors. These may not concern the routine tester, but may mislead research workers. For example, Dr. Busvine uses Ferguson's principle to explain the positive temperature coefficient of toxicity of hydrogen cyanide and the negative coefficient of toxicity of DDT. Ferguson specifically excluded hydrogen cyanide; and his principle can never offer more than a partial explanation for the temperature coefficient of DDT, which may sometimes, in fact, be positive.

There are some omissions. In the sections about humidity, there is no mention of saturation deficiency —a method for expressing humidity measurements with which many biologists are unfamiliar, and which could well be brought into a book like this. There is no general section about the various objective methods for telling whether or not an insect is affected by poison, or for assessing effectiveness in other ways; on the other hand, this question is quite fully dealt with in the section on tests with mosquito larvæ. This emphasis on tests with insects of medical importance is indeed a characteristic of the whole book.

The final chapter is about "Toxicological Statistics", or methods for planning tests and for assessing their results. It is refreshing to note that Dr. Busvine calls for moderate use of statistics when results are prepared for publication.

The lay-out of the book does not make for the greatest efficiency in use. There is no index. Instead, there is a systematically arranged table of contents, which is a list of some of the many headings that occur in the text. The material is classified and subclassified so much that there are ten different types of heading; as many as five of these may occur on one page, some of them often more than once. Many readers will find this irritating. In addition, some topics may be hard to find, because the material is not always logically set out. Thus, under "General Principles of Insecticide Testing" we find, besides some experimental detail, an account of the various aims that experimenters may have in mind when planning their tests; general principles are found under "Toxicological Statistics". The effects of temperature and humidity after treatment are described under "Standardisation of Insects for Testing". Probits are mentioned casually from place to place in the body of the book, but are not defined until well into the last chapter.

This book is not perfect, but it should be useful all the same, especially as it is the first of its kind. There are more than 550 references, covering all the important branches of the subject.

A. H. MCINTOSH

## GENERAL ENTOMOLOGY

### A General Textbook of Entomology

Including the Anatomy, Physiology, Development and Classification of Insects. By A. D. Imms. Ninth edition, entirely revised by Prof. O. W. Richards and R. G. Davies. Pp. x+886. (London: Methuen and Co., Ltd., 1957.) 75*s*. net.

WHEN in 1925 A. D. Imms published his "General Textbook of Entomology" it at once became clear that here was a synthesis of a major field of zoology which was likely to prove to be an outstanding work in its sphere for at least half a century. The third revised enlarged edition of 1934 served to maintain the value and prestige of the work, but the subsequent so-called editions, from the fourth (1938) to the eighth (1951), were mere reprints and the book has thus been falling far behind as the already great development of the subject increased in momentum over the years. The publication, therefore, of a ninth edition is of great value, and it can be said that the authors have done a difficult job outstandingly well. It is scarcely possible, even if it were desirable, to attempt a minute critique of a work containing

such an immense amount of detail; for the great merit of Imms's text-book was the masterly way in which he condensed an enormous amount of information into a relatively short space (750 pages) with a wonderful flair for retaining what is really important.

In the new edition the original format and layout have been retained and we are obviously dealing with 'the same book'. But it has been enlarged by nearly 200 pages, on almost every one of which there seems to be some significant change. As the editors point out, about 4,000 papers and books on insects now appear annually, and such an output from the production line does indeed set an almost impossible task to would-be summarizers. Obviously much must be left out. The editors have made their selection with sound judgment. They could, of course, have cut out the physiological side entirely and thus greatly eased their task. It would, I think, have been a great pity to have done this, and although the physiological chapters cannot be, from the nature of the case, as full and thorough as the rest, to have left them out would have so changed the nature of the book as to deprive it of one, at least, of its great merits. Quite apart from the great and steady increase in the quantity of publications on the insects, the task involved as a result of the mere increase in the number of described species is almost overwhelming. Perhaps we get the best idea of this increase if we compare two of the main groups. In 1925 the text-book writer was concerned with 50,000 species of Diptera, comprising 45 families. He now has to deal with 64,000 species classified into 83 families. In the Hymenoptera the classification has not been extended very much although the described species have risen from 60,000 to 100,000. All this has, of course, to be expressed in the general classification.

The original "Imms" classified the Insecta into 23 orders, grouped in two sub-classes. R. Jeannel in Grassé's recent text-book adopts a modified Martynov classification of 40 recent orders comprised in two sub-classes and 15 super orders. Brues and Melander (1932) had 34 orders against Imms's original 25. Prof. Richards, in the new edition of "Imms", has been very conservative in this. He considers that while many of the new divisions adopted by Handlirsch (1908), Martynov (1938) and others are probably justified and certainly desirable in attempting to incorporate the much greater knowledge of fossil insects that we now have, many of the innovations are of doubtful success; so although a number of the changes are, in principle, approved and receive critical discussion, the layout of the scheme of classification has not been very greatly changed. The general student is at least spared the task of having to remember 35 or so recent orders, being let off with 29.

Among the sections in the latest edition which can be regarded as mainly new are the general ones on classification, sections of those on the musculature, physiology of the nervous system, sense organs and perception and on digestion. The section on the physiology of respiration does not seem to have quite kept pace with some of the rest; and neither the account of the air sacs nor that of the mode of action of the closed tracheal system is quite as clear and precise as would now be possible and as might have been expected. However, there is a good new account of the blood and blood system and an excellent short summary of the present state of knowledge on endocrines.

Perhaps the most important new feature of the book is the large number of new and important keys which it provides. Almost all the main orders have received some new treatment in this respect and particularly outstanding are the new keys to the Diptera, the Hymenoptera and the Coleoptera, the last being largely based on the work of Crowson. There is no doubt at all that the keys to these three main orders have been enormously improved. The increase in the number of illustrations has not kept pace with that of the text; in fact the new edition has somewhat fewer than the old. This is, perhaps, rather a pity and it would seem that more of the old figures might have been discarded for new ones. Where changes have been made, however, they seem to be excellent and in particular some of the new illustrations of the external morphology of the Hymenoptera will be very useful. Considering the book as a whole there is no doubt that it is an eminently worthy revision of a really outstanding text-book, and not much higher praise than that can be given. It should, with enough subsequent less intensive revisions, enable the work to retain its place in the forefront for many years.

W. H. THORPE

# EASTER ISLAND CULTURE

## Aku-Aku

The Secret of Easter Island. By Thor Heyerdahl. Pp. 368+37 plates. (London: George Allen and Unwin, Ltd., 1958.) 21*s*. net.

EIGHT years after Thor Heyerdahl made his epic voyage on the *Kon Tiki* raft, he returned to Polynesia with an archæological expedition to undertake a study of Easter Island culture. The initial results are given in this vividly written and finely illustrated book. As well as accumulating a great deal of general information about Easter Island culture, the expedition performed two very important services. Some of its members engaged in much more extensive scientific excavation than any earlier visitors had done, while Heyerdahl himself discovered a series of family caves with curiously carved stone figures of novel type.

The book sets out to show that the secret of Easter Island, including the 'mystery' of how its giant statues came to be, has now been solved. But the anthropological reader may well feel that the author, in solving some problems, has only created some new ones. It is good to have the actual proof by word and photograph of how these enormous statues can have been hauled along the ground by ropes and raised by wooden levers on stone ramps to their upright position. But this is confirmation rather than discovery of method. Métraux, in 1934, was told of the embankments and ramps by means of which the statues were brought to the level of the platform on which they would be placed, and also of wooden levers, crushed potatoes and round stones which helped these heavy masses to slide along. Even in 1914 Mrs. Routledge had found behind some statues the mounds of stones which had supported them while they were being raised into a vertical position. But Heyerdahl's organizing gift of enlisting enthusiastic co-operation has now given us a practical demonstration.

The weights involved still remain somewhat obscure. Heyerdahl speaks of 180 people pulling a statue of 12 tons and of twelve men raising a statue

weighing between 25 and 30 tons. He also talks of one, of which the density and measurements were obtained, weighing 50 tons. Métraux, taking the density of the volcanic tufa as 2.48, as measured in the Laboratory of Geology, Paris, calculated that statues of this material which were actually transported weighed only 5–6 tons, although others still at the site of manufacture were as much as five times that weight. Heyerdahl is critical of the estimates of his predecessors and speaks of the rock as very hard ("hard as bone inside the outer surface"), but gives us no precise data from which comparative estimates can be checked.

The stone figures from the caves raise questions only meticulous study can answer. By a combination of friendliness, gifts, ingenious bluff and playing on the Easter Islanders' notions of spirits, Heyerdahl obtained access to a number of caves, the secret of which appears to have been most carefully guarded from previous investigators. He is to be congratulated on a magnificent feat of persistent inquiry and discovery. But the results of this exciting story as yet are still rather puzzling. These extraordinary figures, which all seem quite small, include bearded heads, stone skulls, a three-masted 'reed boat', a whale with a house on its back, a woman with a fish roped to her shoulders. Who made them ? From the photographs and description some appear to be ancient specimens. Others look like relatively modern work. Heyerdahl himself says that some stone figures were ancient, that some were made by the father and the grandfather of the woman from whom he received them, that some other figures, allegedly from the caves, were made as fakes to sell to him and treated to look old, and that the 'mayor' of the island, a superb carver, rigged up a complete cave of bogus figures in an attempt to hoax him. Out of this medley, selection of the genuine traditional specimens cannot have been simple. Moreover, we are still almost without a clue as to their meaning.

The book concludes with a restatement of the author's contentions as to the American origin of Polynesian culture—arguments based so far on very debatable evidence. We therefore await with interest the detailed analysis of the expedition's archæological findings.

RAYMOND FIRTH

## THE YEASTS

### The Chemistry and Biology of Yeasts

Edited by A. H. Cook. Pp. xii+763. (New York : Academic Press, Inc. ; London : Academic Books, Ltd., 1958.) 22 dollars.

YEASTS have been studied for many years because of their importance in fermentation industries, and this has led to the building up of a large amount of miscellaneous information, most of it directly related to industrial practice, but including also many studies of more general application. More recently, interest in yeasts has intensified and much work of a fundamental nature has been done on the biology and biochemistry of these organisms. The time is therefore opportune for an authoritative and comprehensive survey of what is known about yeasts. The book under review has this as its aim and it hits the target very near the bull's eye. Perhaps the best idea of the scope and standard of the work may be conveyed by a list of the subjects treated, with their authors' names : yeast classification (J. Lodder, W. Ch. Slooff and N. J. W. Kreger-van-Rij), ecology (A. Lund), life-history and cytology (Ö. Winge and C. Roberts), genetics (Ö. Winge and C. Roberts), chemical composition (A. A. Eddy), growth (E. O. Morris), fermentation and respiration (F. F. Nord and S. Weiss), synthesis and degradation of cellular carbohydrates (W. E. Trevelyan), nitrogen metabolism (G. Harris), technology (Magnus Pyke), pathogenicity (G. C. Ainsworth), food spoilage activities (M. Ingram), and flocculation (H. E. Jarsen). The success or failure of a collection of individual articles such as this, however, depends not only on the contributors, but also to a large extent on the editor. In this case, the editor, A. H. Cook, has obtained admirable results ; his team of authors is well balanced and includes some with a world-wide reputation ; these authors have obviously been well coached so that there is a reasonable uniformity of style ; their areas of activity have been adequately defined so that while the field is well covered there is little unnecessary overlapping, and their articles all come up to a very high standard of freedom from linguistic errors and misprints.

It is not possible to comment on each article individually within the space of a short review, but in many ways they are remarkably similar. Each article surveys the present state of knowledge in a particular field, with special attention to work published within the past few years ; it is subdivided under headings, sub-headings, and in some cases sub-sub-headings; it is well illustrated with figures and tables and is followed by an alphabetical list of references, which in every case includes literature up to 1956 or 1957. There are some outstanding articles by authors who, while contributing largely to the field they review, have been able to give an objective view of the subject as a whole ; these are authoritative and critical surveys of great value. Other articles do not quite come up to this high standard. The articles are followed by an author index (containing about 2,500 names) and a subject index (69 pages). Altogether, the book is by far the best available statement of our present knowledge of yeasts.

I should have liked fuller discussion of adaptation, autolysis, sulphur metabolism, the Pasteur effect and of the formation of esters and other secondary products of fermentation, but there would be difficulty in deciding what to leave out in order to make space for this new material. In the author index I found almost every name which came to mind, but in the subject-index under the letter 'A' I failed to find acetal, acetyl methyl carbinol, actidione, adaptation, adaptive enzymes, aeration, amyl alcohol or azide ; no mention of the first three of these was found in the text, but the remainder are mentioned in the text and some are indexed under other headings (enzymes adaptive, *iso*-amyl alcohol and sodium azide); this indicates that the cross-referencing might be improved. Other changes that could be recommended are that footnotes should be eliminated, and that the magnification should be indicated on the photomicrographs where it is missing. One other criticism which might be made is that the price is high ; but the paper, printing and binding of the book are of the highest quality and, if this is the cost of producing such a book, then we must pay it, because we would not wish for any lowering of the standard of production and because access to this book is a necessity for everyone who is working with yeasts.

R. B. GILLILAND

## Annual Review of Nuclear Science

Vol. 7. Edited by James G. Beckerley, in association with Robert Hofstadter and Leonard I. Schiff. Pp. viii+496. (Palo Alto, Calif.: Annual Reviews, Inc., 1957. Published in co-operation with the National Research Council of the National Academy of Sciences.) 7 dollars.

VOLUME 7 of the "Annual Reviews of Nuclear Science" contains the following twelve contributions: Mu-Meson Physics, J. Rainwater; Radiochemical Separations by Ion Exchange, K. A. Kraus and F. Nelson; Equipment for High Level Radiochemical Processes, N. B. Garden and E. Nielsen; Cellular Radiobiology, E. L. Powers; Biochemical Effects of Ionizing Radiation, B. E. Holmes; Vertebrate Radiobiology (Lethal Actions and Associated Effects), V. P. Bond and J. S. Robertson; Vertebrate Radiobiology (The Pathology of Radiation Exposure), C. C. Lushbaugh; The Collective Model of Nuclei, F. Villars; Nuclear and Nucleon Scattering of High-Energy Electrons, R. Hofstadter; Collision of $\lesssim$ 1 BeV. Particles (excluding Electrons and Photons) with Nuclei, S. J. Lindenbaum; The Measurement of the Nuclear Spins and Static Moments of Radioactive Isotopes, W. A. Nierenberg; Hyperons and Heavy Mesons (Systematics and Decay), M. Gell-Mann and A. H. Rosenfeld.

The articles in this volume are up to the very high standard which we have come to expect in this series. Most of them represent excellent up-to-date surveys which, in different ways, should be equally valuable to the expert or the new research student who wants a readable introduction to a new field and is overwhelmed by the published literature. The review by Rainwater and, to a much lesser extent, that by Gell-Mann and Rosenfeld were written at an inopportune time. They were concluded within a few months of the discovery of parity violation in weak interactions, when these subjects were in a state of violent change. As a result, much experimental work done since their completion is missing from these surveys and theoretical conjectures based on conflicting or sparse data would be on sounder foundation to-day.

It would seem most desirable to be able to buy individual articles (friends of authors may already be lucky enough to receive such complimentary copies) at a small fraction of the present price.

F. MANDL

## Nuclear Chemical Engineering

By Prof. Manson Benedict and Prof. Thomas H. Pigford. (McGraw-Hill Series in Nuclear Engineering.) Pp. xiv+594. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 71*s.* 6*d.*

A WIDE interpretation of the title is possible, but the authors have made it clear that they are concerned with the materials of importance in nuclear reactors and the novel processes which have been developed to concentrate, purify, and separate them. The use of nuclear radiations in processing materials is not dealt with.

The strength of the book lies in its very thorough theoretical treatment of the various flow sheets which have either been developed or grown in importance as a result of the growth of nuclear power. On this subject the reader will expect much from two such distinguished authors, and he will not be disappointed.

The thermal nuclear reactor is treated simply as a chemical engineering process and, rightly, no attempt has been made to summarize the theory of nuclear reactors. Fuel flow sheets are developed for a typical reactor. Although the principles are well presented, a more critical review of the effects of the assumptions on the results would be welcomed.

Two chapters deal with the production and properties of uranium, zirconium, thorium and beryllium, but no mention is made of graphite. There is an excellent description of solvent extraction processes.

The chemical and radioactive properties of irradiated fuel receive adequate treatment, as does the separation of reactor products. A very thorough and well-written account of the theory of isotope separation and applications is given.

The production is good except for the poor photographs. The authors' wide experience of industry and university has resulted in the production of a first-class book which is highly recommended.

W. MURGATROYD

## Progress in Biophysics and Biophysical Chemistry

Vol. 8. Edited by Prof. J. A. V. Butler and Prof. B. Katz. (Progress Series.) Pp. viii+409. (London and New York: Pergamon Press, 1957.) 105*s.* net.

THIS volume has four articles on various aspects of protein synthesis and the nucleic acids, and five others on hearing, colour vision, bacterial electrochemistry, the nerve axon and red cell permeability. No doubt they will all be of value, and some will certainly be of great value, to specialists in these fields. But it is not to this clientele that the editors say they address themselves. They aim higher and "believe that collections of critical reviews of this kind will help to provide a meeting ground for all those scientists who, in spite of their very different methods of approach, are concerned with the applications of physical principles to biology".

In judging their success it must not be forgotten that the scientific reader out to widen his acquaintance is an extremely shy person. In a good deal of the book, unfortunately, the approach is not likely to charm his hesitancy. We can scarcely blame the editors for this, for it is notoriously difficult to extract from the expert a critical account of the fundamental facts and ideas current in his subject, and to get it written in sufficiently attractive and explicit language to be interesting and intelligible to his scientific neighbours. Rather we must be grateful to them, and count their book a success, for the two or three outstanding articles it contains which do possess the rare qualities needed to make friends and influence people.

P. A. MERTON

## An Introduction to Probability Theory and Its Applications

Vol. 1. By Prof. William Feller. Second edition. (Wiley Publications in Statistics.) Pp. xv+461. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 86*s.* net.

THIS, the second edition of Prof. Feller's well-known book, contains a new chapter on "Fluctuations in Coin Tossing and Random Walks", and in it results obtained earlier by advanced methods are now deduced by elementary means. Throughout the book there is increased emphasis on waiting times.

There is a rather remarkable aspect of duality pervading the account. The theory of probability is developed with a degree of rigour which should satisfy the pure mathematician. But there are also applica-

tions to practical situations, including the estimation of the size of an animal population, the distribution of misprints in a book, or of raisins in a cake, or of flaws in a material; and the exposition is made the more colourful by reference to card games, birthdays and the spread of rumours.

The later chapters include one on random walk and ruin, and several covering Markov chains, recurrent events and time-dependent stochastic processes. These topics, apart from their current interest to research workers, have important applications in the study of industrial operations, and an example of the latter is the subject of machine interference, an aspect of which is treated on pp. 416–422.

The book is very well produced and only one error has been noticed. On p. 164, $x^3$ not $x$ should appear in the definition of $\varphi(x)$; the same mistake occurs on p. 166. The title page still describes the work as Volume 1. But it is generally known that Volume 2 has not appeared, and it is believed that it will not appear. On the other hand, on p. 173 it is still stated that a certain matter "must be postponed to the second Volume". Thus, an enigma still surrounds the present work, and it would be good if the publishers could clarify the position. L. S. Goddard

## The Birds of the British Isles

By Dr. David Armitage Bannerman. Vol. 7: Anatidae (Conclusion). Pp. x+256+27 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1958.) 63*s*. net.

Dr. BANNERMAN'S seventh volume covers the dabbling and diving ducks, including the sawbills. He has been able to draw upon even richer material than usual, as the ducks have always been special favourites of some ornithological writers, such as J. G. Millais; they are also well known to sportsmen, who have added to the store of information—especially about habits in winter-quarters in Africa and southern Asia. In our own day and country, too, wildfowl have been the subject of special inquiries into their numbers and habits; not least interesting is the increase, within living memory, of the British breeding populations of several species formerly scarce at that season. Yet again, ducks can be caught for ringing not only when young but also in decoys in winter; and they yield a good proportion of recovery records. Thus, for example, the author is able to quote descriptions of breeding harlequin (a remarkably rare visitor to us) in Iceland and of wintering garganey (one of our less common summer birds) on an equatorial lagoon; and he can cite records of ducks ringed in Britain that have travelled far into the U.S.S.R. The late George Lodge had likewise fine scope for his art in depicting the many distinctively plumaged drakes, contrasted with their relatively sombre mates; one would have liked some of the ducklings as well. Landsborough Thomson

## Natural Selection and Heredity

By P. M. Sheppard. Pp. 212. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 18*s*. net.

If this book had been entitled "Natural Selection and Mendelian Heredity" with a sub-title *à la* Darwin, "Or an account of Speciation according to neo-Mendelian Principles", and had stopped at the end of Chapter 8, it could be called a good book. It is clearly written; at least, as clearly as the intricacies of the neoMendelian hypothesis will allow. But it is not certain for whom it was written. In some places it explains matter with a simplicity which is almost childish (p. 116), while at others it demands a mind of marked mathematical acuity to follow the argument (p. 107).

However, after having devoted eight chapters—just two-thirds of the book—to the "agents" which "control speciation", the author deals with protective coloration (for some reason which is obscure), with mimicry where one hoped for some modern enlightenment on this intricate problem, with a chapter of six pages on ecological genetics, and then, *mirabile dictu*, a chapter entitled "The Origin of Species". After all this there is a conclusion where it is naïvely stated that all the evidence (dealt with so superficially in the last four chapters) supports the idea that the major advances in evolution, the origin of orders, classes and phyla, are controlled by a mechanism "in no way different" from the neoMendelian tortuosities described at such length in the earlier part of the book. The fact that nowhere in the book is the origin of a new structure dealt with is overlooked. Since all the major steps in the evolutionary scale involve the appearance of entirely new structures, this surely detracts from the value of the argument. However, does this matter? The author admits the possibility of cytoplasmic inheritance (p. 171), and throughout the book deals with environmental variation (p. 63), and this, coupled with the recent statement by one of our leading neoMendelians in a review of three books, whose authors have had the temerity to write on evolution, that, of course, "the nucleus is not alone responsible for heredity", makes one wonder whether the present book has anything more than a purely hypothetical interest.

H. Graham Cannon

## Sixth Symposium (International) on Combustion

Yale University, New Haven, Connecticut, August 19–24, 1956. Pp. xxv+943. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957. Published for The Combustion Institute.) 224*s*.

This weighty volume contains 125 original papers, of which six are invited surveys and most of the rest report original work, either theoretical or experimental. Group subjects include laminar and turbulent flame propagation, fast reactions and fast flame stabilization, combustion chamber instability, ignition, combustion of liquid and solid fuels and of explosives, techniques and applications.

The publishers' work has been excellently done, but one could wish that the editors had insisted upon the provision of abstracts uniform in location and style. Many of the papers lack this feature entirely.

The meagre discussion is incompletely reported. It is scarcely fair to record critics' comments and not the authors' replies. The reverse is disconcerting. If this is the best that can be done, the space had better be saved. Reports of three panel discussions are of more interest, especially the first and most substantial on "Future Problems in Combustion Research".

Some of the papers are unsatisfactory in that the date of the Symposium rather than the state of the work has rather obviously been the factor determining publication. Despite any or all such criticisms, however, the book contains a wealth of material that will probably justify the high price in the eyes of the many workers in the field of combustion.

J. H. Burgoyne

# AN EXPERIMENTAL SOLUTION TO THE PARADOX OF DISCONTINUOUS RESPIRATION IN INSECTS

By ROBERT I. LEVY and Dr. HOWARD A. SCHNEIDERMAN
Department of Zoology, Cornell University, Ithaca, New York

IN pupæ of the Cecropia silkworm, *Hyalophora cecropia*, as in many other insects, most of the metabolic carbon dioxide is retained within the insect and released in bursts during brief periods when the spiracles are widely open, which may occur only three or four times each day[1]. Shortly after the burst of carbon dioxide, the valve at the opening of each spiracle flutters for a few moments and then constricts almost completely, remaining motionless for as long as an hour. Following this silent period, the valve begins to pulse and then flutter faintly, slightly enlarging the spiracular opening. Fluttering continues, often for several hours, until the next period of wide opening and release of carbon dioxide. Between bursts, only a trace of carbon dioxide escapes. Notwithstanding this cyclical behaviour of the spiracular valves and the resulting discontinuous release of carbon dioxide, the oxygen uptake of the pupa appears almost continuous[2]. We are thus faced with the perplexing fact that oxygen enters the pupæ during the interburst period at 6–100 times the rate at which carbon dioxide leaves. How can the spiracles, which are the sole site of gas exchange[2], allow oxygen to enter, but effectively bar the release of carbon dioxide?

During the past five years, numerous explanations have been offered for the disparate rates of gas exchange[3]. We have even imagined a 'Maxwell's demon' at the entrance of each spiracle, which lets in oxygen but holds back carbon dioxide. Buck[4] has recently claimed that the disparate rates of interburst oxygen and carbon dioxide exchange are inexplicable on the basis of simple physical diffusion. He proposes that a partial vacuum develops within the tracheal system after spiracular constriction because oxygen is taken up faster by the tissues than carbon dioxide is given up. The possibility of such a vacuum developing within the tracheal system of an insect was first pointed out by Wigglesworth and Herford[5], who noted that the tracheal system of fleas collapsed rhythmically because of a negative barometric pressure within it. In the case of the silkworm pupa, Buck argues that the air inflow caused by the suction impedes the diffusive escape of carbon dioxide from the tracheal system. This attractive theory is unsupported by direct measurements of gas concentrations in the tracheæ (in fact, no true measurements of this sort exist), or by measurements of the time course of the supposed gas changes. To provide this information and to test the theory, we have developed techniques for measuring the composition of the gas in the pupal tracheal system during the respiratory cycle. The present article describes briefly how such measurements were accomplished and provides the first direct and repeated measurements of the composition of the tracheal gas of an insect. The measurements confirm the theory and thus resolve the paradox of discontinuous respiration.

Glass cannulæ were inserted into one or more of the fourteen spiracles of the insect to a point just beyond the spiracular valve, sealed in place with paraffin and filled with mercury. Cannulated pupæ continued to give bursts of carbon dioxide. A fine pipette was inserted into the cannula through the mercury seal and into the tracheal manifold (Fig. 1), and 0·5 mm.$^3$ of gas was withdrawn from the tracheal system at intervals of 10–45 min. over periods as long as 24 hr.; the gas was analysed for oxygen and carbon dioxide with the micro-gas-analyser of Scholander[6]. Nearly one thousand such samples were obtained from about twenty *Hyalophora* pupæ, and their analyses (accurate to 0·3 per cent) revealed striking cyclical changes in the tracheal tensions of carbon dioxide and oxygen that corresponded to the cycle of carbon dioxide bursts.

The overall gas exchange of a pupa with a typical cycle of about 1 hr. duration was measured manometrically in a Warburg apparatus and is recorded in Fig. 2*A*. Tracheal gas analysis was carried out on the same pupa less than 2 hr. after the Warburg record was made. The results, Fig. 2*B*, reveal cyclical changes in tracheal carbon dioxide and oxygen tensions corresponding to the gas exchange results recorded manometrically. Gas analysis results for another pupa are presented in Fig. 3, which also reveals striking cyclical changes in the tensions of the tracheal gas.

Similar results were obtained from other pupæ, and it is clear that the cyclical changes in gas tension may conveniently be divided into three phases: (1) a period during which oxygen tension rises sharply and carbon dioxide tension falls, which we term the 'burst'; (2) a period during which oxygen tension falls steadily and the carbon dioxide tension slowly rises, which we call the 'oxygen fall period'; (3) a

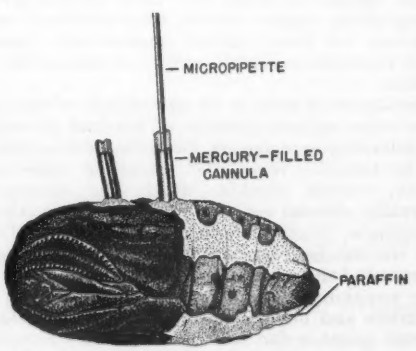


Fig. 1. Micropipette entering tracheal system of a *Hyalophora* pupa through mercury-sealed glass cannula in third abdominal spiracle. The pipette is about 0·3 mm. in diameter

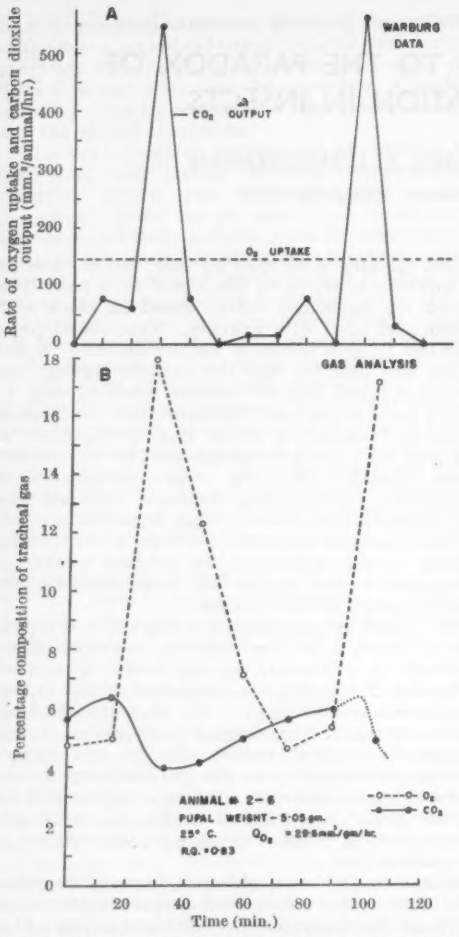


Fig. 2 (*A*) Warburg record of oxygen uptake and carbon dioxide output of a pupa. The cycles of carbon dioxide 'bursts' are clearly evident

(*B*) Record of changes in the tracheal gas tensions of the same pupa during the carbon dioxide 'burst' cycle. The two records have been given the same time axis to emphasize their correlation

period which we term the 'level oxygen period', during which oxygen tension, after suddenly ceasing its steady fall, levels off and remains fairly constant, while the carbon dioxide tension continues its slow increase.

Simultaneous records of movements of the spiracular valve and composition of tracheal gas suggest the following explanation for these cyclical changes in the latter. When the spiracular valve opens widely, carbon dioxide, which has accumulated internally, diffuses out of the tracheal system through the spiracle. Simultaneously, atmospheric air diffuses into the tracheal system, almost equilibrating the internal and the external oxygen tensions. The valve, after remaining open for a time, flutters and then constricts and lies still. With the valve in its constricted position the spiracular aperture is so small that it impedes the diffusive entry of oxygen and, as the pupal tissues respire, oxygen tension within the tracheal system drops sharply, and the tensions of carbon dioxide and nitrogen rise. Finally, oxygen tension falls to a critical threshold, which for most pupæ at 25° C. is about 3·6 per cent, and this initiates valve fluttering. This fluttering lets in enough oxygen to level off and even cause a slight rise in the internal oxygen tension. The fluttering also allows some carbon dioxide and nitrogen to escape from the tracheal system, thereby causing a levelling or slight drop in internal nitrogen tension and an almost imperceptible decrease in the rate of accumulation of carbon dioxide. During the periods of valve closure and fluttering, the internal carbon dioxide tension rises slowly and steadily from 3 per cent to about 6·4 per cent, the slowness being a consequence of the buffering action of the blood. Finally, when carbon dioxide tension in the blood and tissues (which are in equilibrium with the tracheal carbon dioxide) reaches a critical threshold, the valve opens widely, carbon dioxide diffuses out in a burst, air rushes in and the cycle begins again.

Thus the spiracular valve exhibits two distinct kinds of response to two different stimuli. Low oxygen tension causes partial, graded, relaxation of the spiracular muscle and fluttering of the valve. High carbon dioxide tension produces an all-or-none response: muscle relaxation and wide opening of the valve. Our results persuade us that, contrary to apparent doubts[7], fluttering is a normal response of the spiracle and is triggered off by oxygen tension.

This control of fluttering by oxygen tension is shown dramatically in records of valve movements at varying oxygen tensions. Oxygen tensions greater than about 50 per cent eliminate fluttering entirely and leave only the all-or-none response to carbon dioxide[1]. If the level-oxygen period is, in fact, a consequence of fluttering, as we suggest, one would anticipate that since no valve fluttering occurs in pupæ exposed to high oxygen tensions, analysis of tracheal gas would fail to reveal a level-oxygen period. This prediction is borne out in the results presented in Fig. 4, which describes the changes in composition of tracheal gases of a pupa maintained in 59 per cent oxygen. The period of decrease in oxygen tension is greatly lengthened and the level oxygen period disappears entirely. Apparently with high external oxygen tension, the tracheal oxygen tension never falls low enough to trigger off the fluttering responsible for the level-oxygen period. This result re-emphasizes that the spiracular mechanism is sensitive to lack of oxygen as well as to accumulation of carbon dioxide[8].

The present experiments provide one final piece of information. They give direct experimental support for Buck's theoretical explanation of the paradoxical disparate rates of gas exchange during the interburst period[4]. Employing the most extreme values found in our analysis of tracheal gases for the gradients for diffusive entry of oxygen and exit of carbon dioxide, a simple calculation using Fick's law of diffusion shows that these gradients would permit at most a five-fold difference in transfer-rates of diffusion. Hence we are forced to conclude that simple diffusion alone cannot account for the gas exchange of the pupa during the interburst. This conclusion, although it contradicts our usual ideas about insect respiration, is inescapable. Something other than the simple thermal agitation of molecules is responsible for driving oxygen into the insect at up to a hundred times the rate at which carbon dioxide leaves. The answer is apparently this.

When the spiracles close at the end of a burst, oxygen is used up faster than it enters, and the tracheal oxygen tensions falls. That is, the spiracular

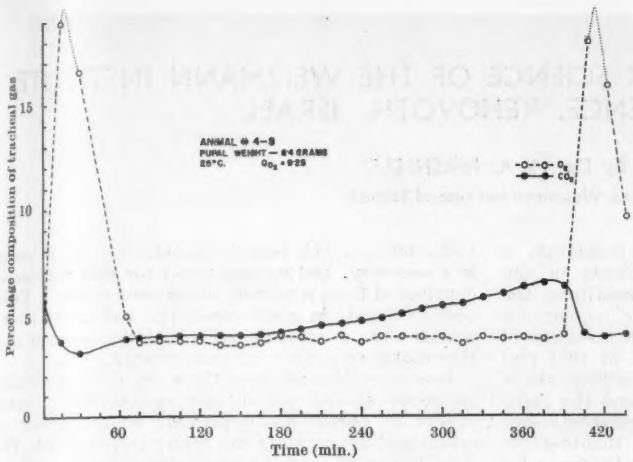


Fig. 3. Record of changes in the tracheal gas tensions of a pupa with a long carbon dioxide 'burst' cycle

openings are so small during this period of falling oxygen tension that they limit the inward diffusion of oxygen. Since a large proportion of the carbon dioxide molecules produced is dissolved and buffered by the blood, for every five molecules of oxygen used perhaps only one carbon dioxide molecule enters the tracheal gas space. This means that gradually the total number of gas molecules within the tracheal system decreases and the internal barometric pressure gradually falls. In other words, the absolute pressure within the tracheal system falls below atmospheric as the result of oxygen utilization. The consequences of this difference in pressure are tremendous. It means that through the tiny spiracular opening a stream of air will flow into the tracheal system following, not a diffusion gradient which depends on partial pressures, but a gradient of absolute pressure. In effect, the insect maintains in the tracheal system, a partial vacuum and sucks in air molecules. This mass inflow of air will not only bring in oxygen but also impede the outward diffusion of carbon dioxide and lead to a build-up of this gas within the insect that will persist as long as the spiracular opening is kept small. Nitrogen will also accumulate, since it is being sucked in with the air. Eventually, carbon dioxide accumulation in the blood triggers open the spiracles, the vacuum disappears and now gases inside and outside the insect mix by simple diffusion. Direct evidence for this postulated mass inflow of gas is seen in records of tracheal gas tensions, as the following considerations show.

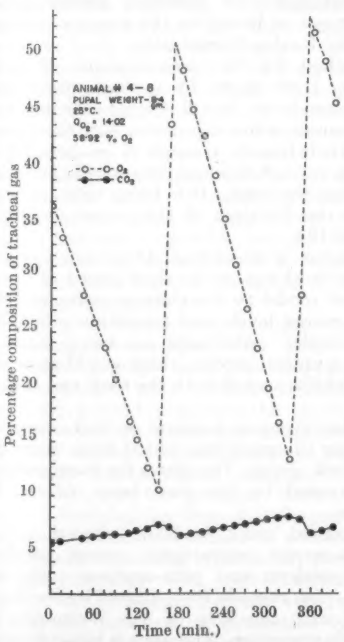


Fig. 4. Record of changes in tracheal gas tensions of a pupa maintained in 59 per cent oxygen

In Fig. 4 it is evident that during the oxygen fall period the oxygen tension within the insect falls at a steady rate which is independent of the gradient of partial pressure driving oxygen into the insect. If simple diffusion were the driving force behind the entry of oxygen, the rate of fall of internal oxygen tension would diminish as the gradient driving oxygen is increased. This is not the case. If, however, oxygen entered by mass flow, then the rate of fall of oxygen tension would remain the same during the entire oxygen fall period, because the number of oxygen molecules entering the tracheal system would be determined almost entirely by the difference in total pressure between the outside and the inside. This is borne out by the observations.

In summary, we see that for most of the time the gas exchange of the pupa is not governed, as we have long thought, by the laws of simple diffusion, in which thermal agitation of molecules is the driving force, but by a different set of laws that govern the mass transfer of gases, where the motive force is difference in absolute pressure. Since discontinuous respiration with its bursts of carbon dioxide is not uncommon among insect orders, and is found in larvæ, pupæ and adults[9], it appears that we may have to re-evaluate several of our usual motions about how some insects breathe.

We wish to thank Mr. Raphael Poritzky for drawing the figures. A detailed description of the methods and complete report of the results of the experiment is in preparation. The investigation has been supported by Grant *H*-1887 from the National Heart Institute of the U.S. Public Health Service.

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# INSTITUTE OF NUCLEAR SCIENCE OF THE WEIZMANN INSTITUTE OF SCIENCE, REHOVOTH, ISRAEL

By Dr. M. A. HIRSHFELD
The Weizmann Institute of Science

THE Institute of Nuclear Science, Rehovoth, is the most recently completed building of the group of scientific institutions which constitutes the Weizmann Memorial, dedicated to the memory of the late Dr. Chaim Weizmann, the first president of Israel. The memorial was established in 1952 and included the already existing Weizmann Institute of Science, the Sieff Research Institute and the Agricultural Research Station. Since its establishment, there has been added the Wolfson Building for Experimental Biology, the Wix Auditorium for lectures and scientific meetings, and the Institute of Nuclear Science. The Institute was dedicated on May 20, 1958, at a formal ceremony in the presence of the President of Israel; addresses were delivered by the Prime Minister, Prof. Niels Bohr and J. Robert Oppenheimer. The dedication was followed by a symposium in the exact sciences: among the participants were physicists from many countries, including Niels Bohr, H. C. Urey, G. Herzberg, J. E. Mayer, J. R. Oppenheimer, J. Weisskopf, S. Chandrasekhar, L. Néel and F. Bloch.

The Institute is set in the midst of the orange groves which surround Rehovoth, overlooking a spacious lawn, flower-beds and lily pond. The building is modern in style, all white, with simple rectangular lines. The main section, covering 4,600 square metres, has two floors above ground and a basement and sub-basement below. The west wing of this section houses the Department of Nuclear Physics; the east wing houses the Electronics, Spectroscopy and Nuclear Magnetic Resonance Sections, as well as the library and seminar rooms. Directly behind the Department of Nuclear Physics is a wing which houses the Department of Isotopes Research with one floor above ground and one below. Connecting the two sections is a corridor containing the common services—machine shop, electronics workshop, electrical distribution centre and administrative offices. The Van de Graaff tower is a separate structure, between the Departments of Nuclear Physics and Isotope Research, connected to both on the basement and sub-basement level. The spectroscopic laboratories are, as usual, located on the sub-basement level to reduce the amount of vibration and temperature fluctuation.

All the services are distributed to the individual rooms through the sub-basement, which extends under the entire building; the wiring and pipes are exposed as much as possible for maximum accessibility. The services include the usual gas, oxygen and compressed air, as well as vacuum and distilled water in the laboratories which require them. The electric lines supplied to outlets in each laboratory include 220 volts from the national grid, 110 volts and a stabilized 220 volts, all at 50 c./s. Free lines from the distribution centre are also connected, which can be used to supply direct current up to 220 volts, either from a generator or storage batteries, or 110 volts, 60 c./s. In Israel's climate, air conditioning is a necessity, and cooling water for this purpose is distributed from a central compressor station. Each corridor—and, in some cases, the individual laboratories—has a separate air circulation system and thermostat to control its own climate.

Because of the nature of the work, it was necessary to adopt special precautions against the harmful effects of radiation—to prevent contamination of rooms and instruments and injury to personnel. The Van de Graaff machine was isolated for this reason. The handling of all radioactive materials will be subject to centralized control. A film badge and blood-testing service will be set up to prevent excessive exposure of the scientists and technicians working in dangerous areas.

The Department of Nuclear Physics, with eight laboratories, the electronics workshop and its offices, occupies about half the main section. Most of the experimental work centres about the Van de Graaff generator, which is housed in a separate, shielded tower and is connected to the main building on the basement and sub-basement levels. The Van de Graaff is a 3-million-volt accelerator; it can deliver up to 100 microamperes and has exceptionally good voltage stability. Among the projects planned are measurements on the energy-levels of light nuclei, the investigation of Delbrück scattering and the measurement of life-times ($10^{-9}$ sec.) of energy-levels excited by Coulomb excitation.

A method for the measurement of very short ($10^{-11}$ sec.) life-times of excited states has been designed and built. It will be used with artificial radioactive sources or in conjunction with the pulsed beam of the Van de Graaff. It employs two beta-ray spectrometers in coincidence and uses microwave techniques to measure the time. It is being used, at present, to measure the life-time of the lowest excited state of platinum-195.

A number of theoretical physicists in the department are working on the shell model of the nucleus, using this model to correlate experimental data and predict energy-levels and transition probabilities for related nuclei. Attempts are being made, too, to develop a unified model, which would incorporate the successful features of both the shell and the collective model.

Another group is working on high-energy physics, measuring the particles ejected from 'stars' produced by 4·5 BeV. pions. The plates for these measurements were exposed to the pion beam of the Berkeley bevatron.

Theoretical work is being carried out as well on high-energy interactions—meson production in nucleon–nucleon and pion–nucleon collisions. The nucleon–pion cascade is calculated by the Monte Carlo method with the help of the Weizmann Institute electronic computer. The work is being done in collaboration with the Department of Isotopes Research.

Fig. 1. The Institute of Nuclear Science, Weizmann Institute of Science

The Department of Isotopes Research occupies the rear wing of the building. It has twenty-three laboratories plus facilities for high- and low-level radioactivity work. One of its major activities has been the construction of a plant for the concentration of oxygen-17 and oxygen-18 by the multi-stage fractional distillation of water; it produces concentrations of the former up to 2·0 atomic per cent and of the latter up to 95 atomic per cent. The enriched oxygen isotopes are being used in studying such problems as the point of bond breaking in ester hydrolysis, the exchange of oxygen between organic compounds and water, and the isotope effect in the infra-red spectra of molecules. Four mass spectrometers are available for this work, two of which were constructed at the Institute.

For work with radioactive isotopes special low-level counting rooms have been built using the Faraday cage principle and low-temperature scintillation equipment with coincidence circuits. The projects being worked on include the use of carbon-14 to follow the carbon chain rearrangements during hydration of olefins, and iodine-131 to trace iodine exchange with iodo-aromatic compounds. In co-operation with the Government Water Planning Authority, a study of the flow of underground water is being made, using radiocobalt as a tracer as well as the naturally occurring tritium. A project being carried out together with the Nuclear Physics Department is the isolation of the very short-lived fission products obtained by irradiation of uranium with the thermal neutrons from the Van de Graaff generator. The Department also operates a radio-isotope school for training scientists, engineers, physicians and science teachers in the applications of radioisotopes.

The Electronics Department is located in the right wing of the building and consists of nine laboratories. Its facilities comprise a 4 in. laboratory electro-magnet and associated instruments built in the Department for the measurement of the magnetic properties of ferro-magnetic substances. There are facilities for the making and shaping of ferrites and standard electronic laboratory equipment.

The research done in these laboratories is in large part connected with the theory of magnetic materials and crossed-field electronic elements. A new process for magnetization reversal has been proposed in the theory of small particle magnets; it had been assumed heretofore that magnetization reversal took place by rotation in unison of the magnetization vectors of the ferro-magnetic ions. It has now been shown that processes called 'curling' and 'buckling' have lower energy and will take place. The results of this theory agree better with the known coercive forces of such magnets.

Work has been done on a crossed-field magnetic amplifier. A clip-on milliammeter based on this amplifier was constructed, and investigations were carried out on a magnetic flip-flop circuit.

Various scientific instruments have been developed in collaboration with other departments of the Institute and outside groups as well. These include several viscometers; one—a microviscometer to measure small amounts of biological substances—is now being used for research in the University of

Birmingham. Another is a high-precision couette viscometer where electrostatic forces are used to supply the restoring torque.

The Spectroscopy Section occupies eight laboratories in the basement and sub-basement of the main building. The work of the section centres around the measurement of the refractive index of gases and liquids in the infra-red. The measurement of dispersion in regions of absorption is a new approach to the problem of measuring intensities in the infra-red. It yields the same information—by an entirely independent method and possibly with improved accuracy.

Located in a laboratory in the sub-basement to provide a stable environment is the large spectrometer-refractometer for the measurement of the dispersion of gases. Designed and built at the Institute, it comprises a high-resolution grating spectrometer and a hollow-prism refractometer of very high sensitivity ($1 \times 10^{-7}$ index units or better); the instrument is evacuated to eliminate atmospheric absorption. Because of the high resolution and sensitivity, the refractive index can be measured through the individual lines of the rotation–vibration bands of a gas. Measurements are being made at present on diatomic gases in the 1·5 micron region and will soon be extended to longer wave-lengths.

To measure dispersion in absorbing liquids, a Perkin–Elmer infra-red spectrometer is being used, together with a specially built critical angle refractometer. Because of the complications introduced by the absorption, the Weizmann Institute electronic computer is used to reduce the results. A method has now been developed for measuring refractive indices of moderately absorbing liquids.

Also available are a large and medium quartz spectrograph for spectrographic analysis and research in the visible and ultra-violet.

The Nuclear Magnetic Resonance Section occupies four laboratories, including chemical preparation rooms. The major piece of equipment is the high-resolution spectrometer which was constructed at the Institute. It utilizes a permanent magnet with a field strength of 7,100 oersteds. The magnet is provided with field homogenizing current shims and a sample spinning turbine. The residual inhomogeneity on a sample of 0·2 cubic centimetre is $10^{-4}$ oersteds or less. The radio-frequency equipment is tuned to proton frequency only and a specially designed pulsing system eliminates balancing problems. A spin-echo apparatus and unit for solid-state work (a 4-in. electromagnet and Pound spectrometer) are also available.

The nuclear magnetic resonance method is being used to study the rates and mechanisms of very fast proton exchange reactions in solution. The shape of the lines is related to the mean life-time of the molecules between successive proton jumps; the measurements, therefore, enable precise kinetic data to be obtained for very high speed reactions. The reactions being studied are the *p*H-dependent proton exchange in solutions of amines, amides, hydrogen peroxide, water, etc. Work is also being done on the magnitudes and signs of spin–spin constants in liquids, on double quantum transitions, on the Maser effect and on a general theory of exchange narrowing.

# NEWS and VIEWS

## Applied Electron Physics at the Imperial College of Science and Technology: Prof. Dennis Gabor, F.R.S.

Dr. Dennis Gabor, who has been appointed to a newly created university chair of applied electron physics tenable at the Imperial College of Science and Technology, London, was born in Budapest in 1900. He studied electrical engineering in Budapest and Berlin-Charlottenburg, and after taking the Dr.Ing. degree entered the Siemens-Halske organization, Berlin, as research engineer in 1927. In 1934 he joined the Research Laboratory of the British Thomson-Houston Co., Rugby, and in 1949 he became Mullard reader in electronics in the Department of Electrical Engineering at the Imperial College. He was elected a Fellow of the Royal Society in 1956. Dr. Gabor's research work has covered an unusually wide field and has been characterized by a remarkable inventiveness. Few scientists can have attempted the impossible so frequently or have been so little discouraged by failure to achieve it. After working on high-speed cathode-ray oscillographs, gas-discharge lamps with positive characteristic, light-amplifiers and three-dimensional cinematography, he was attracted in 1944 by the general problem of transmitting information. He created a mathematical framework modelled on quantum theory, now known as 'structural' communication theory, which bridged the gap between the time-description and the Fourier-description of signals, and followed this by a composite of experimental excursions into wave-band-saving invention and of theoretical work on the application of communication theory to physics, in particular to physical optics. He later devised a new method of obtaining optical images by 'wave-front reconstruction' which he still hopes might be applied to improving the resolution of electron microscopes. He is at present engaged on the development of a thin, flat, television tube for application to colour television. His many admirers will wish him well in this difficult undertaking.

## Geography at Birmingham: Prof. R. H. Kinvig

The retirement of Prof. R. H. Kinvig marks the end of the first thirty-four years of the Department of Geography at the University of Birmingham. He was appointed there as reader in 1924 to establish the Department, and under his guidance it has become a flourishing honours school from which have graduated several present-day holders of chairs, and a centre for geographical research, especially on the Midlands, with a fine map collection specializing in maps of Birmingham and its region. A Liverpudlian, Kinvig early developed a life-long interest in the Isle of Man, and his "History of the Isle of Man" (1944) shows his wide interest in both historical and human geography. At Birmingham he initiated local studies by his essay on the North-west Midlands for the volume on Great Britain prepared for the International Geographical Union Congress of 1928, and

his own continued interest is shown in his editorship of the British Association volume on Birmingham (1950), and his work on the Domesday geography of Warwickshire. He has also travelled widely, and his resulting writings have done much to stimulate studies in Latin America, Poland and southern Africa. His services to the University were recognized by the conferment of a professorship in 1950 and to his subject by his election to the presidency of Section E of the British Association (which he long served as recorder) in 1953, and the presidency of the Institute of British Geographers in 1957.

### Prof. David L. Linton

Prof. D. L. Linton, who has held the chair of geography at Sheffield since 1945, has been appointed to succeed Prof. Kinvig at Birmingham. He is now among the most senior of those who graduated from the new honours schools of geography established after the First World War, taking first a general degree in science and then a special degree in geography in 1927 from the Joint School of Geography of King's College, London, and the London School of Economics. He shares with his former teacher and life-long friend and associate in research, Prof. S. W. Wooldridge, an especial interest in geomorphology. He was appointed to the chair at Sheffield at the age of thirty-eight (*Nature*, 106, 106; 1945) after service in his old college, King's, and Edinburgh, and a distinguished career in the R.A.F.V.R., where his special talents were used in photographic interpretation. There, as in all his later work, his critical and incisive thinking often resulted in new and fresh interpretations of familiar features. This is seen in his work on delimitation of morphological regions, on drainage patterns and the origin of tors, and in his presidential address to Section E of the British Association in 1957. His long and unobtrusive service as honorary editor of *Geography* is reflected in the current high standing of that journal. Before taking up his duties in Birmingham he is spending a year on research in the Falklands.

### Space Science Board

The U.S. National Academy of Sciences has announced the formation of a sixteen-man Space Science Board, "to survey in concert the scientific problems, opportunities and implications of man's advance into space". Dr. Lloyd V. Berkner, president of Associated Universities, Inc., president of the International Council of Scientific Unions and a member of the National Academy of Sciences, is to be the chairman. The Board, besides acting as the focal point for all Academy and National Research Council activities connected with space-science research, will be called upon to co-ordinate its work with appropriate civilian and government agencies, particularly the proposed National Aeronautical and Space Agency, the National Science Foundation, and the Advanced Research Projects Agency, and with foreign groups active in this field.

### Darwin, Demography and Development of Life

Three outstanding lectures have now been made available to bigger audiences. The first, by Sir Gavin de Beer, is his well-known lecture on Charles Darwin in the Master-Mind Series of the British Academy (pp. 24. Oxford University Press, 1958. 3*s*. 6*d*.). Besides a succinct introduction to Darwin's life and thought, the lecture provides an admirable exposition of the pre-eminent place of natural selection among contemporary theories of evolution. The second, by the grandson of the genius whom de Beer honoured in his lecture, is the 1958 Rede Lecture, in which Sir Charles Darwin expounds the belief that the present rapid increase in world population holds threats for the future outweighing completely any of the menaces that preoccupy statesmen and politicians (pp. ii+42. Cambridge University Press, 1958. 3*s*. 6*d*.). The third is the inaugural lecture by the recently appointed Quain professor of botany in the University of London, Prof. David Lewis ("The Experimental Approach to Life". Pp. 17. London: H. K. Lewis and Co., Ltd., 1958. 2*s*. 6*d*.). In his lecture, Lewis discusses the experimental approach to life, and shows how physics and chemistry are beginning to play an equally important part with biology. The invasion of biology by physics and chemistry has created a crisis that must be resolved by all who are concerned in biological teaching and research. In research the crisis is partly met by establishing departments of biochemistry and biophysics, but this does not solve the immediate problem of training biologists, which must be carried out in departments of botany and zoology.

### Oversea Visual Aids Centre, London

As a result of the unanimous request of an Oversea Visual Aids Conference held in 1956, a Centre has been set up in London from which advice and help will be given on all aspects of audio-visual aids. The Centre, which is to be known as the Oversea Visual Aids Centre (O.V.A.C.), is sponsored by H.M. Government and the Nuffield Foundation. Its director is Mr. G. H. Busbridger, who served in the Educational Service in Northern Rhodesia for many years and afterwards became director of Education in Tanganyika Territory. The Centre has started its activities at Tavistock House, Tavistock Square, London, W.C.1, while alterations are being made to premises at 31 Tavistock Square, which will become its permanent headquarters towards the end of the year. The Centre is controlled by a Board of Governors under the chairmanship of Mr. L. Farrer-Brown, director of the Nuffield Foundation. The Centre will have on permanent display a wide range of projected and non-projected aids, so that visitors can see for themselves examples of the latest equipment used by British manufacturers, as well as cheap non-projected aids made from local materials. It will organize training in the educational use of all kinds of audio-visual aids, in the handling and maintenance of equipment and in techniques of making simple aids from cheap materials. In addition to these services, Governments and individuals overseas will be kept informed of new developments by regular publications.

### River Pollution in Britain

In its first report to the Central Advisory Water Committee (pp. 10. London: H.M. Stationery Office, 1958. 9*d*. net), the Trade Effluents Sub-Committee, appointed in October 1956 with Sir Frederick Armer as chairman, to examine existing legislation and the operation of the common law respecting the disposal from trade premises of liquid effluents, concludes that the time has not yet arrived for dispensing with the consent of the Minister of Housing and Local Government before river boards

can prosecute for pollution of rivers. It recommends accordingly that the original seven-year period of the Rivers (Prevention of Pollution) Act, 1951, should be extended from 1958 to 1961. In the report, which has been unanimously adopted by the main committee, the sub-committee concludes that, while it is true that river boards generally have shown forbearance, in view of the financial implications of their requirements on industry as well as on local authorities, and through them on the country as a whole, they ought not to disregard the fears of those who are concerned lest they be caught between the difficulties of capital restriction on one hand and possible prosecution on the other. It also seemed desirable to allow a little extra time to industry to pursue research on effluent treatment and to river boards to prepare by-laws laying down permissible standards for effluents. The Committee remarks that it is now embarking on its general review of the law on this subject.

## Aslib : Report of the Council

The report of the Council of the Association of Special Libraries and Information Bureaux for the year ended December 31, 1957, presented at the annual general meeting of Aslib on June 3, records a further increase in membership, from 2,095 to 2,254, including twenty-six technical colleges. Industrial and commercial firms still form the largest single category, totalling 831, compared with 753 at the end of 1956. Besides the acquisition of new and larger premises (3 Belgrave Square, London, S.W.1) which should permit Aslib to develop a research section, establish an exhibition of equipment for library and information work, and expand its library to serve also as a laboratory for testing and demonstrating library equipment and processes, several new short courses were organized during the year, including those on advanced classification, the handling of Russian and other East European literature and the treatment of periodicals. Three special conferences held in London dealt with library services in technical colleges, the preservation of business records and the availability of information on nuclear energy. A grant of £10,000 was received from the National Science Foundation to finance a two-year research project into the efficiency of selected indexing systems, while, with the Royal Society, Aslib is co-ordinating British participation in an International Conference on Scientific Information to be held in Washington in November 1958.

## Forest Products Research Laboratory

The Council for Scientific and Industrial Research has decided that research on the following subjects should be undertaken at the Forest Products Research Laboratory : (1) the pulping properties of home-grown timbers ; (2) more work on the general properties of home-grown timbers. An additional scientific officer will be appointed to take charge of the work on pulping. Otherwise all the staff required are to be provided by transfer from other existing work at the Laboratory. The Research Council has also decided that it is not possible to continue indefinitely at the public expense all the work which is at present carried out on timber bending, wood working, composite wood and wood protection. The value of the work is not questioned, but it is considered that the industries concerned which benefit from the work should do it themselves, or pay for it to be done. The Department is therefore informing the industries concerned that its expenditure on work in these fields will diminish progressively and will end in five years time. It will thus be open to industry to carry out the work or to pay the Forest Products Research Laboratory to do it.

## Yale Medical Library

The annual report of the Yale Medical Library for 1956–57, which includes the report of the Historical Library, covers the year ended June 30, 1957 (pp. 33. New Haven, Conn. : Yale University, 1957), and records an increase of more than 160 per cent in the endowed book funds, income from which now approaches 10 per cent of the amount appropriated for purchasing books and periodicals. The film-room maintained by the Library, together with the Audio Visual Centre, seats fifty people, and now contains a 16-mm. sound projector, a slide projector and a microfilm reader, and its use has steadily increased. Accessions of 6,161 during the year brought the Library's holdings to 295,252 volumes (including books, pamphlets and serials) and 26,469 volumes were circulated for outside use, besides 1,055 in inter-library loans. The Library, which has an outstanding collection of Western manuscripts, is one of the foremost in the United States in the richness of its collections for the physician, the scientist and the historian.

## Royal College of Science and Technology, Glasgow

The annual report of the Royal College of Science and Technology, Glasgow, for the year 1956–57, records the initiation of no major developments during that year. During the next ten years the University Grants Committee wishes the College to provide for a student body rising to 2,500. During the quinquennium 1957–62, developments on the teaching side will be mainly to cope with the larger numbers, reduce the size of classes and increase the facilities for advanced study and research. In the reports from Departments, reference is made to the study in the Department of Mathematics of the diffusion of momentum when a jet issues into an outside medium, and the variation of concentration when the jet and the outside medium consist of gases of different kinds ; to a varied programme of research in the Department of Natural Philosophy, including an examination of strains of the bacterium *Proteus vulgaris*, and completion of an investigation on the transmission and absorption of highly reflecting films ; extension of the research on paddle wheel propulsion in the Department of Naval Architecture, in conjunction with William Denny and Bros., Ltd., by an investigation of the relation between the model results and those from ship trials. In the School of Pharmacy a new series of neuromuscular blocking agents was prepared. A list of recent publications is also included, but further information on research in progress in the various departments is contained in the Report on Research for the Session (pp. 39. Glasgow : Royal College of Science and Technology, 1958). This lists publications departmentally, with a brief abstract of each.

## Publications of the Oak Ridge National Laboratory

A list of articles in scientific and technical journals and of unclassified reports published during 1957 by members of the staff of the Oak Ridge National

Laboratory has recently been issued (Pp. v+34. Oak Ridge National Laboratory, Union Carbide Corporation, 1958). The articles and reports are listed in separate sections and classified in alphabetical order of authors under the general headings: biology, chemistry, engineering, general, health physics, instrumentation, mathematics, metallurgy and materials, and physics. Many of the papers are available free as reprints from the Central Research Library, Oak Ridge National Laboratory, P.O. Box *X*, Oak Ridge, Tennessee, and others may be purchased through the Office of Technical Services, Department of Commerce, Washington 25, D.C. Some articles were published in 1956, but were not issued until 1957; the 1956 and 1957 articles are distinguished by the prefixes '56' and '57', respectively, before the reference numbers. The authors' names, title of paper and journal reference are given in every case.

## Alkali Works in Britain

THE ninety-fourth Annual Report on Alkali, etc., Works in England and Wales (pp. 50. London: H.M. Stationery Office, 1958. 3*s*. net) by the Chief Inspector covers the year 1957, when the number of works registered decreased by seventeen to 872 and the number of processes by fourteen to 1,733, due to the concentration of manufacturing operations, particularly at gas-works and by-product plants. The 4,023 units and inspections during the year included 174 special visits by the chief and deputy chief inspectors and nine by Mr. W. A. Damon, who since March has been engaged on special advisory duties. Of the total, 430 visits were to or in connexion with works not registered under the Act, and a further 55 visits were in connexion with colliery spoilbanks. Besides 2,175 quantitative analyses made of gases evolved from the processes in question during the inspections, 965 samples were submitted for detailed examination to the Government Chemist. Complaints were most numerous against cement works and fertilizer granulation plants, and escapes of fumes in excess of statutory limits were recorded on seven occasions, a further ten infractions related to failure to use the "best practical means", the total infractions comparing with 23 in 1956 and 48 in 1955. A general survey of emissions of smoke, grit and dust from registered operations indicated that reasonably satisfactory conditions already exist generally.

Under the same cover is included the annual report for 1957 of the Chief Inspector for Scotland, where the number of registered works decreased by nine to 71 and of processes requiring inspection by thirteen to 101. In the 148 visits of inspection, 56 chemical tests were made. Of the five complaints lodged about fumes from registered works, three related to granulated fertilizer plants and two to paraffin oil works.

## Industrial Research in East Africa

THE annual report for 1956–57 of the East African Industrial Research Board (pp. ii+8. Nairobi: Government Printer, 1957. Sh. 2) records continued trials on the production of vitreous white-ware bodies, and attempts are now being made to adapt the process to native industry. In the manufacture of bricks and tiles, relatively large additions of sawdust have been possible to some clays, probably those containing a fusible lava, with consequent increased fuel economies, and a pilot-scale continuous kiln has been designed for reconstituting meerschaum from the waste in producing tobacco pipes. Research continued on the mechanical drying of arabica coffee, and fair results have been obtained in estate practice by two methods which should cause no more damage to quality than sun-drying under difficult conditions. Fully wet coffee is severely damaged by a single-stage drying about 100° F., but the damage is less the lower the initial moisture content at which mechanical drying starts. Serious damage to quality is probably associated with damage to viability. In chemical engineering a preliminary investigation has been made on the possibility of condensing natural steam with a jet condenser or an air-cooled surface condenser, and work has commenced on the use of pressure charges for internal combustion engines and on the economies of drying sisal waste. A further attempt to operate a 40-gallon digester for producing methane from sisal waste failed.

## East Malling Research Station

AN index has been published to provide quick and adequate reference to work carried out at East Malling Research Station and mentioned in the annual research reports since 1913 (Kent Incorporated Society for Promoting Experiments in Horticulture. Abstracts and Index to the Annual Research Reports, 1913–1953, East Malling Research Station, near Maidstone, Kent. Pp. vi+175. East Malling: East Malling Research Station, 1957. 20*s*.). This alone will prove useful to all those concerned with fruit-growing and plantation crops, but the value of the work is greatly enhanced by the fact that the compilers, Dr. F. W. Andrews and Mr. A. C. Painter, have also given a brief abstract of each paper. Thus, a great volume of information has been made available without laborious search. There is an appendix of the pests and diseases mentioned in the reports, under their common English names with their scientific equivalents, including synonyms.

## Lundy Field Society

THE saddest feature of the eleventh annual report of the Lundy Field Society (Lundy Field Society. Eleventh Annual Report, 1957. Pp. 43+2 plates. Exeter: Prof. L. A. Harvey, The University, 1958. 5*s*.) is the reference by the president, Albion P. Harman, to the real decline in the numbers of puffins on the island. The possibility of the puffin disappearing from the island appears to be very great; within a few years it seems unlikely that the bird will breed there. This is almost certainly due to oil pollution of the sea. Another reference in the report is to the remarkable invasion of tits which took place in October 1957. The immigrants included blue tits, coal tits and great tits, and their times of arrivals coincided with similar records made in other parts of Great Britain. Seven birds new to the island were recorded during 1957; these included the little egret, American stint, tawny owl, nightingale, Richard's pipit and red-knecked grebe. A new feature in the report is an account of the many mesolithic flints unearthed by members of the Devonport High School during a stay on the island. The collection included a number of small worked microlithic blades, a microburin, conical cores, several notched blades, and a fine backed burin or graver, all typical of a mesolithic culture, although possibly of a late date.

## A Schoolboy's Survey of Vegetation of a Valley

Blundell's School, Tiverton, may well be proud of R. G. Pembrey, who was awarded the Senior Batterbee Prize in 1957 for an investigation into the factors underlying the differences in vegetation on the north- and south-facing slopes of a steep valley in spring. Pembrey compared the vegetation on the two slopes, analysed the soils at different levels and made observations on the bedding plane of the rocks, recorded environmental factors like soil, temperature and light intensity and made various records comparing the performance of different species on the two slopes. These included the rate of elongation of stems of bramble and yellow archangel, the internode length in ash seedlings, and the times of bursting of beech buds. The differences in the vegetation on the two slopes are due to a more rapid warming of the soil on the south-facing slopes, which allows the growth of a spring ground flora before the bursting of the beech buds. This is directly connected with the far higher light intensity on this slope. On the opposite slope, light intensity and soil temperatures are too low to support a spring flora. A full report of the investigation is described in the *School's Science Magazine*, which contains reports of other interesting work by schoolboys.

## Volcanic Eruptions in Kamchatka

The extinct or dormant volcano Bezymyannyi (also known as Sopka Bezymyannaya), belonging to the Klynchevsky group of volcanoes of Kamchatka, revived its activity on September 29, 1955, in the form of a series of volcanic earthquakes, followed on October 22, 1955, by eruptions terminating, on March 30, 1956, in a gigantic explosion which removed the greater part of the cone and formed a new crater-caldera. The progress of this activity was observed by G. S. Gorshkov and his companions and is described by him in two articles (*Bull. Volcan. Station*, No. 26, *Acad. Sci. U.S.S.R.*, 1957; *Priroda*, **1**, 61; 1958). The violent explosions of this volcano gave rise to large masses of volcanic ash which, mixing with melting snow, formed a series of mud flows, some 60 km. in length with a calculated volume of 3 cubic kilometres. These flows became covered with a large number of secondary fumaroles in such a way that the whole district resembled the Valley of Ten Thousand Smokes of the Katmai eruption of 1912 in Alaska. According to Gorshkov, the calculated total energy of the volcanic explosive activity was $4 \times 10^{23}$ ergs, while the total thermal energy evolved was $3{\cdot}6 \times 10^{23}$ ergs. This shows that the force of the eruption was due to the thermal energy of the magma and that the gas acted mainly as the transformer of the thermal energy into the explosion energy. During the final stages of the eruption a large plug-dome of andesitic lava was intruded in the crater-caldera of the volcano.

## Reduction of Evaporation from Reservoirs

In an article in the *World Meteorological Bulletin* of April 1958 and in a report on the use of cetyl alcohol in solution to reduce evaporation from reservoirs Mr. F. Grundy gives an account of an experiment conducted on Malya reservoir in Tanganyika Territory during August 1957 (Memoirs of the East African Meteorological Department, **2**, No. 11; 1958. Nairobi: East African Meteorological Department, 1958. Sh. 4). The subject is one of particularly great importance in tropical areas where loss of water by evaporation can be several times the volume drawn for use. The work in East Africa began with tests in evaporation pans in the grounds of the Meteorological Office at Nairobi, which showed reduction of loss by about 60 per cent. Work on the Malya reservoir (130 acres) was more difficult because of disturbance by wind, and it was found better to use the alcohol dissolved in such solvents as kerosene rather than in solid form. The solution has to be applied continuously from sources on the upwind shore or preferably, because of better adjustment to wind changes, from a boat. The observations were made during the dry season to avoid complications due to rain. By computing the evaporation-loss from the inflow and outflow and comparing with evaporation from neighbouring evaporation pans it was estimated that the evaporation-loss was reduced by 11 per cent. The amount of cetyl alcohol used was 18 lb./day. It is not poisonous to man or animals, but its effects on fish are not yet known. Mr. Grundy considers that the experiments show an adequate film of cetyl alcohol can be maintained, but that further research is needed, especially on the method of applying the substance and avoiding wastage from its oxidation by organic matter. The cost is not likely to be excessive.

## Nomenclature of Cultivated Plants and of Fungi Pathogenic to Man

It is now generally accepted that agreed international codes of nomenclature are essential to progress and unity of effort in the biological sciences; and cultivated plants, being essential to civilization, should be brought fully within "a precise, stable and internationally accepted system". So states Article 1 of "The International Code of Nomenclature for Cultivated Plants" (1958), now published by the International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy (106 Lange Nieuwstraat, Utrecht, and Royal Horticultural Society, London. 2*s*. 6*d*.). In this short but valuable publication, to which many distinguished botanists have contributed, all relevant issues are considered with clarity and precision. In the same general category, but dealing with very different subject-matter, the Medical Research Council has now published a revised edition of Memorandum No. 23, first issued in 1949 ("Nomenclature of Fungi Pathogenic to Man and Animals—Names recommended for use in Great Britain". Second edition. Pp. iii+14. London: H.M. Stationery Office, 1958. 1*s*. 3*d*. net). Here, again, it is noted how much progress in medical mycology has been hindered by the multiplicity of names for fungi associated with certain human and animal diseases. The nomenclatural issues here can be very complex indeed, and both knowledge and judgment are essential to sound decisions. In this small pamphlet an exacting task has been ably performed.

## Peruvian Orchids

The Orchidaceae not only vie with the Compositae as a family comprising a vast number of species—somewhere between 15,000 and 35,000 according to contemporary estimates—but they are also undoubtedly among the most advanced group of the monocotyledons. A further contribution to our knowledge of this family comes from Peru, where

some 120 genera and 900 species have been recorded. A recent publication deals with 26 genera and 629 species (Chicago Museum of Natural History. *Fieldiana*: *Botany*. Vol. 30, No. 1: Orchids of Peru. By Charles Schweinfurth. Pp. viii+260. (Publication 837.) Chicago: Chicago Natural History Museum, 1958. 4.50 dollars). In the Peruvian and Colombian Andes, indeed, the orchid flora apparently reaches its richest expression. As the author points out, although there have been many collecting expeditions to the Peruvian Andes, and much material stored away in herbaria, no comprehensive flora of the region has been undertaken for 130 years. The monograph is well illustrated by line drawings.

## Biology in the Far East

A CONGRESS has been arranged by the University of Malaya, to be held in Singapore during December 2–9, to celebrate the centenary of the publication of the theory of evolution by Charles Darwin and Alfred Russel Wallace, and the bi-centenary of the publication of the tenth edition of "Systema Naturæ" by Linnæus, and to provide a forum for scientists in South-East Asia who were not able to attend the fifteenth International Congress of Zoology in London in July. Recognition has been given to this Congress by various learned societies which have nominated representatives to attend and contribute papers to the symposia. Financial support has been gained from numerous sources, whereby it has been possible to issue invitations to a number of biologists in various parts of the world to attend the Congress as guests of the University of Malaya. Valuable help is also being given to the organization of relevant exhibitions. The organizers of the Congress hope to enable some distinguished visitors to visit the Federation of Malaya to deliver additional lectures at appropriate places, and it is also expected that the various exhibitions will be sent into the Federation of Malaya for display, so that the maximum benefit can be gained from the occasion.

The Congress will open on December 2 with an address of welcome to the visitors, and a presidential address, followed by lectures introducing the Indo–Malayan region, and the concept of organic evolution. The following six days will be devoted to a series of symposia in the fields of botany, ecology, general systematics, evolution, genetics and anthropology. Visits to local places of interest will be arranged during December 2–9, and a number of excursions will be held immediately afterwards.

Prospective participants should communicate the title of any scientific paper offered, with its length, to Prof. R. D. Purchon, University of Malaya, Singapore, from whom further information can be obtained.

## U.S. National Science Foundation: Senior Postdoctoral Fellowships

THE National Science Foundation, Washington, D.C., has announced the award of 54 science faculty fellowships for the academic year 1958–59, offered as a means of improving the teaching of science, mathematics and engineering in American colleges and universities. The Foundation has also announced the award of 27 senior postdoctoral fellowships in the sciences for the academic year 1958–59, selected from 155 applicants. Science faculty follows were selected from 440 graduates from all parts of the United States and its territories on the basis of demonstrated ability and special aptitude for science teaching and advanced training. Senior postdoctoral fellowships were awarded to scientists with ability and special aptitude for productive scholarship. Ten awards were made in the life sciences, and fifteen in the physical sciences, including a number in interdisciplinary fields. Two awards were made in convergent fields. Science faculty and senior postdoctoral fellowships carry stipends approximately equal to the regular salaries of the recipients. These stipends may be applied towards study or research in an accredited non-profit institution of higher learning in the United States or abroad.

## Announcements

THE ninth International Congress on Astronautics will be held in Amsterdam during August 25–30. Further information can be obtained from the British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1.

THE Golden Jubilee Autumn Meeting of the Institute of Metals will be held in Birmingham during September 22–26. Further information can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

THE next joint meeting of the Challenger Society and representatives from the Marine Laboratories (Development Commissioners' Scheme) will be held at the Dove Marine Laboratory, Cullercoats, and King's College, Newcastle upon Tyne, during September 18 and 19. Further information can be obtained from Dr. H. O. Bull, Dove Marine Laboratory, Cullercoats, North Shields, Northumberland.

THE fourth Reinforced Plastics Technical Conference, organized by the British Plastics Federation, will be held at the Hotel Metropole, Brighton, during October 21–24. There will be sessions on the properties of basic materials, applications, manufacture and user interests. Papers will be preprinted and circulated before the conference. Further details can be obtained from the British Plastics Federation, 47–48 Piccadilly, London, W.1.

THE British Weed Control Conference, 1958, organized jointly by the Society of Chemical Industry and the British Weed Control Council, will be held at the Hotel Metropole, Brighton, during November 3–6. Further information can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

THE National Institute of Agricultural Botany is holding a conference on "Herbage Seed Production" in Cambridge during November 18 and 19. Further information can be obtained from the Secretary of the Institute, at Huntingdon Road, Cambridge.

THE Artemis Press invites submission of manuscripts for a prize of £150, which will be awarded for an academic work in mathematics, astronomy or physics. Both monographs and more general works will be considered; they need not be original in content, but relevance to fundamental topics and elegance of treatment are desirable. All manuscripts submitted will be considered for publication. Further information and entry forms can be obtained from the Artemis Press, Ltd., 25 Walpole Street, London, S.W.3.

## GEOLOGICAL MAP OF THE WORLD

THE Commission for the Geological Map of the World met in Paris during March 31–April 12. This Commission was founded in 1910 at the Stockholm International Congress and has been reorganized twice since the Second World War. At the Mexico International Geological Congress in 1956 two Sub-Commissions were created: (1) for the Tectonic Map of the World, and (2) for the Metallogenic Map of the World. The Paris meeting was organized to establish an international basis and co-ordination for an immediate start on these three maps of the World: geological, tectonic and metallogenic, on an agreed universal scale, legend and principles of construction. The Commission's aim is to promote the construction of such maps for the following regions of the Earth: North America, South America, Europe, Africa, U.S.S.R., Asia, Oceania, Arctic and Antarctic. The Commission is planning to publish a Geological Atlas of the World at the scale 1 :10,000,000 based on maps at the scale of 1 : 5,000,000. The latter scale is suggested for the tectonic and metallogenic maps. Detailed programmes for the realization of these maps were worked out by the Commission and a number of specific recommendations from various countries or groups of countries were accepted. The aim of the metallogenic map is to record the relations between geology, tectonics and the mineral deposits in any given region. It was also suggested that prior to the construction of such maps, mineral maps accompanied by indexes of mineral deposits should be prepared. It is hoped that these maps, at least in manuscript draft form will be ready for display at the International Geological Congress to be held in Copenhagen in 1960.

Sixty-one countries were represented at the Paris meeting by delegates and assisting geologists. The president of the Commission, elected in 1952, is F. Blondel, who is assisted by his secretariat at 20, rue Monsieur, Paris 7e, France. The vice-presidents for the selected regions are as follows: North and Central America, W. D. Johnston, jun.; South America, A. R. Lamego; Europe, A. Bentz; Africa, F. Dixey; U.S.S.R., N. A. Beliaevsky; Asia, V. P. Sondhi; Oceania, J. M. Rayner.

A Select Committee under the presidency of F. Dixey examined suggestions for the general legend of the Geological Map of the World and drafted a set of recommendations. Similar work was done for the tectonic map by the special sub-commission (president, N. S. Shatsky; secretary, A. A. Bogdanov), and for the metallogenic map by the special sub-commission (president, W. D. Johnston, jun.; secretary, P. Routhier). Possibilities of preparing a coal map of Europe were also discussed.

Besides the meetings of the Commissions, a number of meetings dealing with various associated problems were held, such as the International Geological Abstracting Service, presided over by H. M. E. Schurmann, the Committee on Stratigraphy, the Mediterranean-Alpine Committee and others.

During the fortnight's working of the Commission, a number of official receptions were held, which allowed a closer contact between the visiting geologists and their French colleagues, and the strenuous work of the Commission was relieved at the week-end by a visit to the cathedral towns and the castles of the Loire region. The meeting of such a number of geologists from so many countries, animated by the same enthusiasm and purpose, testifies to a most healthy situation in the world of international science. The effective and profitable results of the meeting are, in no small measure, due to the most efficient organization of the Commission by its president and secretariat.

## MUSEUMS ASSOCIATION CONFERENCE

THE sixty-fourth annual conference of the Museums Association was held in London during July 7–12, and was attended by more than 700 delegates, among whom were some 70 members of De Museumdag from Holland. It was held in Britain to enable the British delegates to return in some measure the hospitality and courtesy extended to them on their visit to Amsterdam in 1956.

The meetings were held in the Beveridge Hall of the University of London and the official welcome was given by the Minister of Education (the Right Hon. Geoffrey Lloyd), who stressed the view of his Ministry that there should be more co-operation between local authorities and private bodies in the maintenance of museums. He welcomed the increasing part that museums were taking in the educational field and said that the Government was well aware of the difficulties of the small museum. Various suggestions had been made and meanwhile his Ministry was watching with interest the development of plans for a regional museum service.

During his presidential address Sir Philip Hendy, director of the National Gallery, dealt with various problems in the museum and art gallery field. First, he mentioned that the tremendous assistance given by the Carnegie United Kingdom Trust in the past is likely to be reduced in the future. He expressed the strong opinion of the Association that it should be replaced by Government assistance of a substantial nature. He then dealt with the recent controversy arising from the enlightened provisions of the Finance Act, 1956, whereby works of art could be accepted in payment of death duties. It was discouraging that a difference had arisen between local and national claims over the Chatsworth treasures. He believed that objects of the highest quality should go to the national collections, as they and they alone could provide the proper context and setting for such material. He also felt that the provisions of the Finance Act could be used for other objects that would be useful in building up the collections of local museums and would otherwise be almost certainly exported from Great Britain.

Dr. A. B. de Vries, president of De Museumdag, also spoke and enumerated some of the qualities necessary in a museum curator.

A complete session was given to a discussion concerning museums in the Commonwealth and Overseas with especial reference to the training of curators. Dr. D. B. Harden, chairman, in opening the discussion, referred to the progress that had already been made with training schemes in South Africa and Canada and expressed the hope that an overseas secretary would be appointed at no distant date to deal with the furtherance of international relationships between the home country, the Dominions and other smaller countries within the Commonwealth. Subsequent speakers included professional museum staff from parts of Africa, Pakistan and Singapore. It was stated by Prof. P. L. Shinnie of the University of Ghana that countries which had recently achieved their independence would not be content with having their museums staffed by English people. On the other hand, Africans with good degrees would scarcely be willing to accept museum posts when there were far more attractive openings in the Civil Service. He felt that the training of technicians could be dealt with in Africa but that curators should have the benefit of a European tour of representative institutions. Dr. L. S. Russell, secretary of the Museums Association in Canada, stated that an inquiry had, contrary to the accepted idea, shown that the chief difficulty in that country was not geographical separation but diversity of subject-matter.

Another session, under the chairmanship of Dr. W. E. Swinton, was devoted to museum architecture. It was opened by Mr. Sheppard Fidler, city architect of Birmingham, who described in detail the reconstruction of the galleries which had been so severely bombed during the War. Dr. H. L. C. Jaffé, Amsterdam, dealt with the many building schemes which had taken place in Holland and several other speakers contributed to the discussion.

In proposing a resolution which deplored the continual negative attitude of H.M. Government towards granting assistance to local museums and art galleries, and urging that everything should be done to acquaint those in authority and others with the facts, Sir Mortimer Wheeler felt that the Standing Commission was an eminent body but of no service to provincial museums. He stressed the urgent need for analytical information and considered that a Royal Commission on the whole subject was long overdue. Government help on a modest scale was needed, and he felt an analogy with the successful University Grants Committee was sound and could be fruitful.

At the annual general meeting, Dr. W. E. Swinton, British Museum (Natural History), was elected president and Sir Philip Hendy and Prof. Lionel Robbins vice-presidents for the ensuing year.

A successful feature of the conference was the large number of working parties which had been arranged at the larger museums and art galleries in London. These were much appreciated by both the Dutch and British delegates and led to many useful discussions in which small groups benefited greatly from the expert knowledge of the staffs concerned.

Receptions were on a lavish scale and included an evening one at the National Gallery which was graced by the presence of Her Majesty Queen Elizabeth the Queen Mother, patron of the Museums Association, a spectacular reception at the Guildhall given by the Corporation of London and smaller groups at the Wellcome Historical Museum of Medical Science and the Iveagh Bequest, Kenwood. The annual dinner was held at the Goldsmiths' Hall and the conference concluded with field meetings at Brighton, Petworth House, Saltwood Castle and Canterbury, Cambridge and St. Albans. It was decided to hold the next conference in Worthing during June 15–20, 1959.

# THE BACKGROUND TO SPECIALIST TECHNOLOGICAL EDUCATION

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HOW does, how *should*, the content of a course for the diploma in technology differ from that of a traditional honours degree course? It is the present purpose to attempt, in part, to give an answer to this question. The tradition of technical education, often by apprenticeship, can be traced back to the earliest stages of human society. The educational tradition of scholarly book learning, on the other hand, has evolved only in the past 1 per cent of human existence. The medieval universities and schools took their character almost entirely from the scholarly tradition. Yet it is by a blending of these two kinds of activity that the flowering of modern science has arisen; to produce the change from the agricultural to the industrial stage of human society.

To what extent is present-day education adapted to the needs of our children, in contemporary industrial society? We have in Britain, comparatively, an extremely good educational system. But since society is developing with such rapidity, both recent reforms and further changes appear inevitable. Confining attention to grammar school and college education, the following five points are offered for consideration.

(1) At the Renaissance, attention to ancient writers was a progressive change. But to-day, whether in English, languages, history or the sciences, too little consideration is often given to the past ten, thirty and a hundred years.

(2) Though the medieval scholarly tradition of book learning has already been much blended with practical manual activities, most school and some college laboratories could do with ten times the costly equipment, space and technician assistance, to give fully effective courses.

(3) The medieval scholarly tradition is mainly of 'pure' studies. It is suggested that in the later years of nearly everyone's education there could well be a higher proportion of applied aspects, both those of use to the general citizen and those which are specifically vocational. This could make higher education

both more interesting as well as a better preparation for later life.

(4) While the Renaissance, plus printing, greatly increased the store of written work available for study, the recent upsurge of science has increased our available scientific written knowledge and material equipments vastly more. Dr. D. J. Price, in *Discovery* of June 1956, gives evidence which suggests that our total scientific knowledge is roughly doubling every 10–15 years, and has been doing this for at least two centuries. The rate of increase is about a hundred-fold per century; and thus, since the schooldays of Newton, scientific knowledge seems to have increased by something like a million-fold. This has resulted in (*a*) the extended duration of science courses, and in (*b*) a further specialization in ever narrower sectors of our total knowledge. The special degree course has been built on top of the General, and university entrance is now preceded by a stiff two or three years in the sixth form in schools. But since lecturers and examiners find it very difficult to drop out older points of detail when new data are incorporated into a subject, there is still often an unhealthy overload of factual material to be memorized, as the Science Masters' Association has recently pointed out. One suspects that the amount of work necessary for graduation, a century ago, may have been little or no more than the work necessary for three General Certificate of Education (Advanced Level) science passes to-day—and perhaps the high-school student deserves more public credit for his achievement.

(5) The enormous increase of modern scientific knowledge has necessitated progressive specialization of courses. But one result is that, for each student, a greater proportion of the sectors of modern knowledge remains neglected. On the other hand, in an industrial democracy, it is most desirable that a large proportion of citizens should be properly equipped with a balanced outlook based on all branches of scientific and other knowledge; with "a broad outlook and a sense of spiritual and human values" (Circular 323). Thus a case can be made for devoting some 10 per cent of each week of sixth-form and college time to achieving this end.

The above five points arise partly from the rapidity of scientific advance and partly from the character of earlier scholastic education. They may be summed up as suggesting a further shift of emphasis: (1) from old to new; (2) from book learning to practical; (3) from pure to applied, including vocational; (4) from an encyclopædic to a more selective approach, and to still greater specialization of the main subject; but (5) towards developing, on the side, a balanced and integrated cultural background covering the whole range of modern knowledge.

Viewed in this kind of historical perspective, the real or potential virtues of the new courses for the Diploma in Technology are clearly apparent. The National Council for Technological Awards, which sponsors these courses, has given the teaching colleges considerable freedom in the design of syllabuses, and these are under constant review. Thus, while maintaining a serious academic coverage of principles, many older topics can be dropped out in favour of newer ones of contemporary relevance. The laboratory time of the eight terms at college is reinforced by four six-month periods of actual industrial employment; and the whole emphasis of the later years of the course is deliberately vocational and applied. In many places the importance of a selective rather than an encyclopædic approach is forcefully realized; while each course is at least as specialized as that for a special degree. In addition, there is an earnest groping towards a suitable development of non-vocational liberal studies, to occupy some 10 per cent of the time-table. The entrance requirement for a diploma in technology course is approximately the same as for a university, though National Certificates are recognized besides the General Certificate of Education. Some students are entered by industrial firms, while others come direct from school sixth forms. Most, though not all, diploma courses are conducted on the sandwich principle. Thus, in each of the four (or five) years, two terms at college are succeeded by six months in appropriate industrial employment; and it is expected that after the four years of scientifically and technologically up-to-date education and experience the average diploma holder will be at least as effective a member of his firm as the average graduate becomes after a further year or two of postgraduate training. Incidentally, the diploma qualification is now recognized as at least the equivalent of a degree by the Burnham Committee. Thus, it is also a route for the recruitment of younger school teachers, who will arrive at school with a much fuller understanding of contemporary life.

The annual intake of students to the diploma courses is at present 736, and is rising rapidly. 1957–58 is only the second year of normal enrolment, and in a few years the intake is likely to be several thousand. The courses are mainly conducted in the new colleges of advanced technology, and where there is a research tradition. The students attending come from all parts of the country. By last autumn the number of subjects for which courses had received the provisional approval of the National Council, at the different centres, was as follows:

| | |
|---|---|
| Battersea, London | 7 subjects |
| Birmingham | 7 |
| Northampton, London | 7 |
| Brunel, London | 6 |
| Chelsea, London | 3 |
| Northern, London | 3 |
| Woolwich, London | 3 |
| Borough, London | 2 |
| Loughborough | 2 |
| Cardiff | 1 |
| Kingston, Surrey | 1 |
| Wolverhampton | 1 |

In a few cases these courses have not yet commenced, but on the other hand in some colleges, especially Battersea College, the courses are run in duplicate—sandwich plus full-time.

In conclusion, it may be mentioned that the courses running last spring, numbering forty in all, had the following subject distribution:

| | |
|---|---|
| Mechanical and production engineering | 9 courses |
| Electrical engineering | 8 |
| Applied chemistry, etc. | 7 |
| Physics | 5 |
| Metallurgy | 3 |
| Aeronautical engineering | 2 |
| Chemical engineering | 2 |
| Mathematics | 2 |
| Applied biology | 1 |
| Civil engineering | 1 |

The engineering and other studies which have developed from the basic work done by the old flint knappers, bronze smiths and millwrights are well represented; but there is already one course, at Brunel College, dealing with the industrial aspects of living organisms.

## OPENCAST MINING IN BRITAIN

THE Opencast Coal Bill, which received a second reading in the House of Lords on June 26, repeals the Defence Regulations under which opencast coal operations are now carried on. In moving the second reading, the Minister of Power, Lord Mills, said that the Bill was the last and largest step in replacing by statutory provisions the Defence Regulations relating to land. The Water Bill and the Land Powers (Defence) Bill had been other measures to that end. Lord Mills said that opencast coal working on a substantial scale began in 1942 to help relieve the acute shortage of coal that had then developed, and since then the opencast sites had produced 160 million tons of coal from slightly less than 110,000 acres, mostly agricultural land, or about 0·25 per cent of our total agricultural land. The opencast output was now about 14 million tons a year, about a quarter of which was large coal, and would fall in two or three years to about 4 million tons unless new sites came into production. To avoid a resumption of imports and replacing restrictions on supplies of house coal we must maintain a substantial level of opencast output for some time and would probably need some opencast coal for the next ten years. Lord Mills assured the House that he would give very close attention to the National Coal Board's plans for opencast coal output with the view of maintaining adequate supplies of coal while doing the minimum damage to agriculture and amenity. In recent months we had been able to defer indefinitely the working of several sites and he hoped the improved position would enable us to be a little more selective.

Lord Mills said that when the new Bill came into operation the National Coal Board intended, whenever possible, to obtain the land or rights in land which they needed for opencast working by agreement, and he gave as one reason for the new legislation the high standard of agricultural restoration after opencast coal working which we had developed. To ensure the maintenance of that high standard we must make special arrangements for close Ministerial control of opencast coal production. He stated categorically that it was the Government's intention at least to maintain present standards of restoration, and, in particular, to require the Board, in the national interest, to restore all agricultural land to the general standard laid down in a code of restoration which was adopted in 1951 and is now being improved as a result of recent discussions between his Department and the National Coal Board and the agricultural organizations. This code provides for five years special treatment of restored agricultural land, and under the Bill the Agricultural Departments would continue to carry out this treatment for the Board, while the Forestry Commission would act similarly for woodland.

In explaining the compulsory powers under the Bill, Lord Mills said that, by Clauses 4 and 6, the Board was empowered to acquire the rights needed to hold, for up to ten years, land at present held under requisition from opencast coal disposal points and stocking grounds. Clause 9 provided that no compulsory rights order could be made against an occupied dwelling house, its garden and certain other land held with it, while every compulsory rights order would be subject to confirmation by the Minister of Power under a procedure which ensured a right to object and to have objection heard. In replying on the debate, Lord Mills said that he was convinced that it would have been wrong to suggest any shorter period than ten years for the operation of the Bill. He was not entirely satisfied that the Bill adequately covered the possible effect of opencast coal working on water supplies, but the Government did not intend that the powers it conferred should enable the National Coal Board to over-ride the Water Act, 1945, or bye-laws made under that Act.

## SYNOPTIC CLIMATOLOGY

SYNOPTIC climatology provides mean values and other statistical parameters of the temperature, cloudiness, precipitation and so on, which are related to the type of air mass and the large-scale distribution of air pressure. It differs in this way from the older type of climatology based more or less exclusively on time of year, which lumped all the atmospheric circulation types together. Types of circulation outside the tropics are by no means closely related to season, however, though some are more frequent in one season than in another. Moreover, the weather in a given type can differ greatly from one season to another, as is evident from the difference between winter and summer in the effect on temperature over western Europe of a persistent high-pressure area over Scandinavia. Such an area has easterly winds to the south of it.

Knowledge of the weather associated with a given type is essential to the weather forecaster, who works by first predicting the pressure distribution and then the associated weather. These two stages are more clearly marked in the modern numerical method of forecasting based on the approximate solution of the equations of motion of the atmosphere by replacing the differential coefficients by finite differences than in the older and more subjective method.

A notable contribution to the synoptic climatology of the British Isles was Dr. Belasco's "Characteristics of Air Masses over the British Isles" (Meteorological Office Geophysical Memoir, No. 87 ; 1952).

Now the Weather Service of the Federal German Republic has published an even more elaborate synoptic climatological study in Dr. K. Bürger's work, "Zur Klimatologie der Grosswetterlagen, ein witterungsklimatologischer Beitrag"*. This is a truly monumental record of the synoptic climatology of western Germany (including Berlin). *Witterung*, a useful word for which there is no single equivalent in English, implies "the constant element in a sequence of weather situations over several days", and *Gross-*

* Berichte des Deutschen Wetterdienstes. Nr. 45 (Band 6): Zur Klimatologie der Grosswetterlagen, ein witterungsklimatologischer Beitrag. Von Kurt Bürger. 79 s. mit 2 Abbildungen und 36 Tabellen im Text, sowie 13 Zahlentafeln und 8 Bildtafeln im Anhang. (Offenbach/M.: Deutschen Wetterdienstes, 1958.) 46.60 D.M.

*wetterlage* means "the main constant circulation and main pressure distribution over the area studied during the period for which the weather type (*Witterung*) persists".

Bürger's work is based on the analysis by punched cards of the observations of temperature, cloud and precipitation at Berlin, Bremen, Karlsruhe and Munich over the period 1890–1954 (omitting 1945). Twenty-eight types of circulation (*Grosswetterlage*) are distinguished, taken for the period to 1952 from Hess and Brezowsky's "Katalog der Grosswetterlagen Europas" (Berichte des Deutschen Wetterdienstes U.S.-Zone, Nr. 33; 1952).

The statistics of the types and of the elements considered in relation to the types set out in numerous tables and diagrams with seventy-eight large pages of commentary include the monthly means for each type, with deviations from the means, and much additional information—such as the types which bring the earliest and last frosts and snowfalls of the year.

As an example of the seasonal differences in the weather associated with circulation types it is shown in one of the tables that while southerly and south-easterly winds associated with an anticyclone are nearly the coldest at Berlin in winter, with a mean temperature 5° C. below the seasonal mean, by May they have become warmest, with a mean temperature 3·1° C. above the seasonal mean. There are naturally differences in the effect of different circulation types at the four stations, notably between Bremen and Munich.

The effect of continentality is clearly shown in the dependence of the standard deviations on place and type. The frequency of temperatures and precipitation between specified limits and occasions of extreme values are listed and referred to their circulation type.

There is no discussion of upper air conditions, but perhaps they will be similarly dealt with later.

# EFFECT OF COLCHICINE ON THE UTILIZATION OF LABELLED THYMIDINE DURING CHROMOSOMAL REPRODUCTION

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IT has been accepted that labelled thymidine is incorporated only into deoxyribonucleic acid[1]. Taylor *et al.*[2] used thymidine labelled with tritium to provide information on the mode of chromosome replication, and colchicine was employed to assist in clarifying the way in which the tracer was inherited by the daughter chromosomes in the meristematic cells of roots of *Vicia faba*. Autoradiographs over chromosomes were obtained by the stripping film technique in squash preparations. Taylor and his collaborators grew seedlings in nutrient solution containing thymidine-$^3$H for 8 hr., then transferred the plants to nutrient solution containing a concentration of 0·05 per cent colchicine, and fixed root tips 18 and 42 hr. after the start of labelling. Colchicine, by inhibiting spindle formation, allowed them to distinguish with certainty the first ($X_1$) and second ($X_2$) mitosis after labelling. *C*-metaphases with the normal complement of 12 chromosomes would be expected in the roots fixed at 18 hr. and a high proportion of *C*-metaphases with 24 chromosomes in those fixed after 42 hr.

In *C*-metaphases of $X_1$ cells they report that both chromatids in each of the 12 chromosomes were equally labelled along their length, while in *C*-metaphases of $X_2$ cells usually only one of the chromatids in each of the 24 chromosomes was labelled along its length. A few $X_2$ cells (48 chromosomes) were found in roots fixed after 42 hr., in which about half the chromosomes were unlabelled, the remainder being labelled in one chromatid. In $X_2$ and $X_3$ cells a few chromatids were labelled along only part of their length, but in these instances the sister chromatids were labelled in complementary segments. This exchange was attributed to somatic crossing-over.

These findings were interpreted as showing that the deoxyribonucleic acid is synthesized as an intact unit, and that reproduction in chromosomes which behave as if they consist essentially of one molecule is by means of a template based on a double-helix model, as envisaged by Watson and Crick[3]. In this system each chromatid after replication would consist of two strands, one with 'old' and one with 'new'

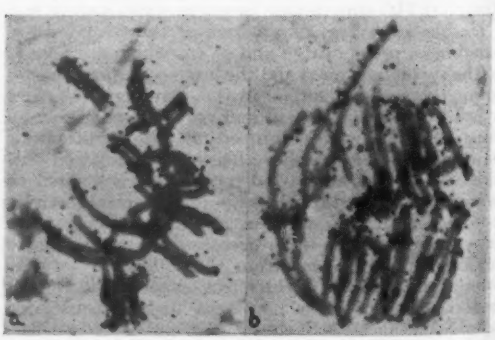


Fig. 1. Autoradiograph of $X_1$ metaphase (*a*) and $X_2$ anaphase (*b*) from roots of *Vicia faba* grown for 12 hr. in tap-water containing thymidine-$^3$H followed by 36 hr. in pure tap-water. Squash preparations stained in toluidine blue after autoradiography. Note in metaphase labelling in both chromatids of *s*-chromosomes at top left and right, unequal labelling in others and at bottom left labelling in discrete homologous regions of both chromatids (× 1,300)

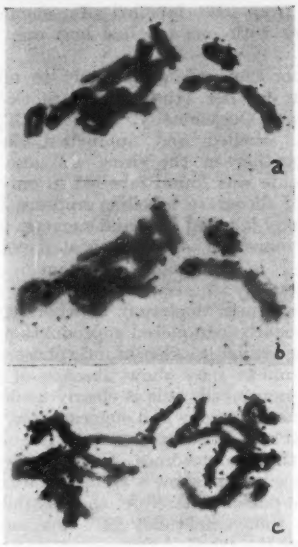


Fig. 2. $X_1$ *C*-metaphase and $X_1$ *C*-anaphase (*c*) from roots of *V. faba* grown for 1 hr. in 0·05 per cent colchicine prior to treatment for 8 hr. with colchicine and thymidine-$^3$H, followed by 0·05 per cent colchicine in tap-water for 12 hr. Squash preparations stained in Feulgen before autoradiography. (*a*) Focused on the chromosomes; (*b*) focused on photographic grains; (*c*) *C*-anaphase. In the metaphase an *M*- and an *S*-chromosome show labelling in one chromatid only; one chromatid of an *S*-chromosome is unlabelled in the *C*-anaphase. (× 1,300)

deoxyribonucleic acid, which are in turn separated during synthesis for the $X_2$ mitosis.

This interpretation, however, is dependent on the supposition that colchicine would in no way influence the process of replication at the $X_2$ interphase. In an initial experiment we therefore dispensed with its use. Seedlings of *V. faba*, with lateral roots, were grown at a temperature of 20° C. in separate containers in tap-water to which thymidine-$^3$H (supplied by Messrs. Schwartz, Inc., New York) was added. Each plant received 25 μc. and the plants were transferred to pure tap-water after 12 hr. Roots were fixed after, 4, 6, 12, 24 and 48 hr. and autoradiographs of squash preparations were prepared by the stripping film technique. The 4-, 6- and 12-hr. samples were considered necessary for comparison with earlier data obtained[4] in *V. faba* with phosphorus-32.

Very few mitotic figures were labelled in the roots fixed after 12 hr., and then only weakly. In roots fixed after both 24 and 48 hr. the autoradiographs were found to be labelled along the length of both chromatids over most metaphase chromosomes (Fig. 1*a*), and also along both daughter chromatids at anaphase (Fig. 1*b*). In the sample fixed after 48 hr., however, some chromosomes with singly labelled chromatids occurred in 12 per cent of the metaphases.

It was necessary to have criteria for distinguishing the $X_1$ and $X_2$ mitoses after labelling. The proportion of interphase nuclei labelled at 4, 24 and 48 hr. is only 20–25 per cent and it can be concluded that the labelled compound is used up after approximately one-quarter of the mitotic cycle (6 hr.). This excludes the possibility of additional labelling during the second period of synthesis of deoxyribonucleic acid and on average the nuclei at the $X_2$ mitosis should contain half the tracer found at $X_1$. After 48 hr. 16 per cent of the metaphases were heavily labelled and can be regarded as $X_1$ mitoses; a similar proportion of $X_1$ and $X_2$ metaphases were found after 48 hr. in a later experiment in which colchicine was used. The average duration of the mitotic cycle in the root meristem of *V. faba* has been found by various methods to be about 24 hr.[4,5], and very few $X_1$ mitoses would be expected after 48 hr. Synthesis of deoxyribonucleic acid lasts for 6–8 hr. and the division 1 hr. after an intervening period of about 8 hr.[4]. It can therefore be expected that no more than one-fifth of the labelled metaphases at 48 hr. were $X_1$.

It was concluded that the results obtained by Taylor and his collaborators were due largely to the extended treatment with colchicine and especially to the fact that only the $X_2$ period of chromosome replication took place in the presence of this agent. It seemed possible that chromosomes with singly labelled chromatids might be obtained at the $X_1$ mitosis by pre-treatment of the roots with colchicine.

Seedlings grown as described before were transferred to tap-water containing a concentration of 0·05 per cent colchicine to which thymidine-$^3$H was

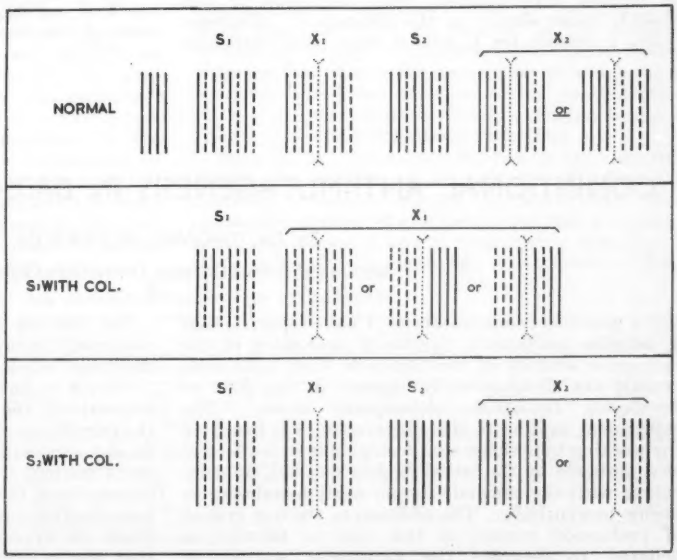


Fig. 3. Scheme of chromosome reproduction assuming four strands before replication. It is assumed that labelled thymidine is available at the first period of synthesis ($S_1$) but not during the second ($S_2$) and that colchicine (*col*) influences the segregation of new and old strands, possibly by an effect on the centromere. In the absence of colchicine the alternative (*or*) at $X_2$ is considered a rare possibility, but this might perhaps explain the results of Plaut and Mazia (ref. 7) with thymidine-$^{14}$C in *Crepis capillaris* if it is assumed that the duration of the mitotic cycle is shorter than in *Vicia* or that the number of strands is different. Strands figured as broken lines are those containing thymidine-$^3$H

added 1 hr. later. This was replaced after 8 hr. by fresh tap-water with colchicine, and roots were fixed after 20 and 24 hr.

In both samples the *C*-metaphases contained some chromosomes labelled along the length of both chromatids and some only along the length of one (Fig. 2*a* and *b*). So far as could be seen, very few *C*-metaphases showed all the 12 chromosomes with labelling in both chromatids. Furthermore, closely similar results to these were obtained in $X_2$ metaphases when we repeated the experiment of Taylor and his collaborators. Complete analysis in tetraploid cells was more difficult, but many *C*-metaphases clearly contained a few chromosomes labelled along the length of both chromatids in addition to those labelled only in one. These observations conflict with those of Taylor *et al.*, and it is justifiable to assume that colchicine can markedly alter the results obtained.

In the presence of a labelled precursor, self-reproduction of deoxyribonucleic acid based on the Watson and Crick model should result in labelled molecules and therefore should never lead to one chromatid of a chromosome being unlabelled at the $X_1$ mitosis. As a working hypothesis, for which cytological evidence is available[6], it is worth while considering that the chromosome may be multiple-stranded at the time of reproduction. If it is assumed that each chromosome consists of four strands before duplication (Fig. 3) and that each chromatid after replication usually consists of two new and two old strands, then the appearance of equally labelled chromatids at both the $X_1$ and $X_2$ mitosis would be expected. If it is further assumed that colchicine could influence the segregation of new and old strands, and hence the distribution of new and old deoxyribonucleic acid, then a situation as envisaged in Fig. 3 could arise. This working hypothesis can be checked experimentally with thymidine-$^3$H and possibly most simply in the absence of colchicine. If this is correct, for *V. faba* at least, grand-daughter cells ($X_3$) from the labelled $X_1$ should contain chromosomes with one labelled and one unlabelled chromatid.

Some other facts that are likely to affect interpretation in further studies were noticed in our experiments. Occasionally, both in $X_1$ and $X_2$ metaphases, labelled and unlabelled chromosomes occurred together in the same cell and twice an *M*-chromosome was found labelled in only one arm. This kind of disparate labelling appears to be confined to weakly labelled cells and suggests that not all the chromosomes in a cell are replicated exactly at the same time. It would become apparent in cells which had undergone synthesis when the store of labelled compound was near depletion, or where the chromosomes had nearly completed reproduction when the label became available. Also, at interphase, small parts of labelled nuclei may show absence of autoradiographs. In many cells this is clearly associated with heterochromatic regions and suggests that these may be replicated at a different time from the euchromatic portions of the chromosomes. Occasionally, however, the interphase nuclei show a similar absence in other chromosome parts. Therefore, the possibility cannot be ignored that sometimes in some parts of the chromosomes the labelled thymidine may perhaps be replaced after synthesis by unlabelled thymidine. No instance of somatic crossing-over was observed, but this possibility must also be considered.


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# CONDITIONAL ANTI-MUTAGENESIS IN *DROSOPHILA MELANOGASTER*


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In a previous communication[1], I have reported that adenine produces a significant depression of the mutagenic activity of formaldehyde when both compounds are simultaneously present in the food of developing *Drosophila melanogaster* larvæ. The experiment leading to this observation was based on the working hypothesis that formaldehyde is effective as a mutagen by the larval feeding method, by competing with the normal (formic acid) metabolite in purine biosynthesis. The addition to the test system of preformed purine, in this case as adenine, is believed to decrease the mutagenic activity of formaldehyde by 'by-passing' the biosynthetic sequence through which formaldehyde is assumed to act. The present communication describes a further observation on the anti-mutagenic activity of adenine towards formaldehyde, consistent with this hypothesis.

The culture medium and methods used are as previously described[1]; Distillers' Co., Ltd., yeast was the yeast employed in the treatment medium.

Curves *a* and *b*, Fig. 1 (see Table 1), illustrate respectively the first and second brood response of the percentage of sex-linked recessive lethal mutations to the concentration of formaldehyde in the treatment medium. The first brood response shows an increase with increasing formaldehyde concentrations, becoming asymptotic at approximately $3{\cdot}0 \times 10^{-2}$ *M*. From the hypothesis, it might therefore be assumed that the response of the first brood to increasing concentrations of formaldehyde (Fig. 1, curve *a*) represents a measure of the extent to which formaldehyde interferes in purine synthesis, the response becoming asymptotic when formaldehyde is saturating the system. The second brood response increases up to approximately $2{\cdot}0 \times 10^{-2}$ *M* form-

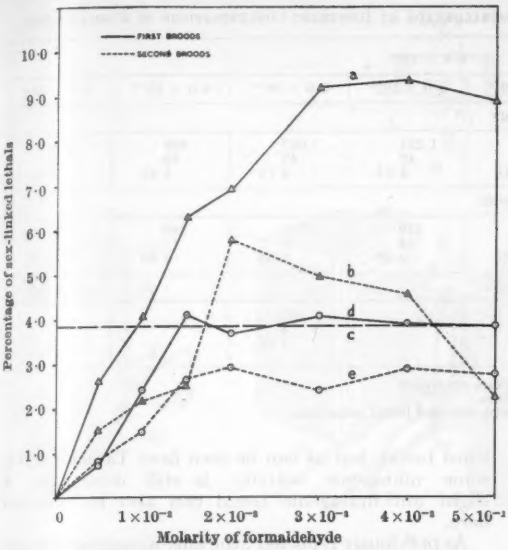


Fig. 1. Anti-mutagenic effect of adenine towards formaldehyde at different concentrations of formaldehyde. Curves *a* and *b* represent respectively the dose-mutagenic response for formaldehyde of the first and second brood; *d* and *e* their response in the presence of the antimutagen, adenine

aldehyde, but falls off at higher concentrations; this latter effect is thought to be due to the increased toxicity of the treatment at the higher concentrations. For the purpose of discussion, it is convenient to consider only the first brood response, owing to the irregularity of response in the second brood.

In the case previously reported[1], the addition of 0·09 per cent adenine ($6·6 \times 10^{-3}$ *M*) to the test medium reduced the mutagenic activity of formaldehyde from 9·72 per cent to 3·37 per cent sex-linked lethals in the first brood, where 0·4 per cent ($4 \times 10^{-2}$ *M*) formaldehyde was used as the test concentration. Thus one might conclude, *ex hypothesi*, that the actual decrease in the mutagenic effectiveness of formaldehyde is due to a corresponding decrease in purine synthesis, produced by the addition of adenine; this decrease is represented by the difference in value recorded for $4·0 \times 10^{-2}$ *M* formaldehyde on curve *a* from that indicated by line *c* (Fig. 1). A reduction of purine synthesis to the level indicated by line *c* is therefore anticipated when this amount of adenine is added to the test medium.

Accordingly, if the formaldehyde concentration is varied by attenuated dosage over the range recorded in the dose-effect curve, the concentration of adenine itself being kept constant at $6·6 \times 10^{-3}$ *M*, a concentration of formaldehyde will be reached (which one might take tentatively as approximately $1·0 \times 10^{-2}$ *M*, see Fig. 1), at which adenine should show no anti-mutagenic effect; this is because the amount of formaldehyde present is at a level with, or less than, that to which purine synthesis is reduced. Thus, one might expect that the anti-mutagenic effectiveness of adenine towards formaldehyde will decrease as the concentration of formaldehyde decreases, until the point is reached at which it might be allowed that the anti-mutagenic effect disappears; at this latter point, and over the sensitive range of formaldehyde concentrations, the mutagenic activity of formaldehyde should therefore be reduced to the level delineated by line *c* (Fig. 1). These conjectures form the basis for the experiments reported here.

In anticipation of the objection that formaldehyde might be removed from the treatment medium by simple chemical combination with adenine, a test was carried out *in vitro* for detection of the extent to which formaldehyde and adenine combine chemically, using the methone method for gravimetric estimation of formaldehyde[2]. At concentrations of $4·0 \times 10^{-2}$ *M* formaldehyde and $6·6 \times 10^{-3}$ *M* adenine, a reduction in formaldehyde concentration to $3·5 \times 10^{-2}$ *M* was detected, which as can be seen by reference to the dose-effect curve (Fig. 1, curve *a*) would have no appreciable effect on the percentage of lethals produced. Indeed, if the anti-mutagenic activity of adenine was one simply involving removal of formaldehyde from the treatment medium by its chemical combination with adenine, the anti-mutagenic activity would be expected to increase with decreasing formaldehyde concentration, since the removal of formaldehyde would be more effective at the lower concentrations. It follows from the working hypothesis that the chemical removal of formaldehyde by adenine is only a consideration at concentrations of formaldehyde actually below that to which purine synthesis is reduced, since at higher concentrations the actual concentration of formaldehyde would be greater than its effective concentration.

Thus Table 2 formulates the results obtained from testing the anti-mutagenic activity of adenine at different concentrations of formaldehyde; these results are illustrated graphically for first and second broods by curves *d* and *e*, respectively (Fig. 1). In the first brood, the mutagenic effectiveness of form-

Table 1. The Dose-effect Response for Formaldehyde

| Molarity of formaldehyde | $0·5 \times 10^{-2}$ | $1·0 \times 10^{-2}$ | $1·5 \times 10^{-2}$ | $2·0 \times 10^{-2}$ | $3·0 \times 10^{-2}$ | $4·0 \times 10^{-2}$ | $5·0 \times 10^{-2}$ |
|---|---|---|---|---|---|---|---|
| **First broods** | | | | | | | |
| *n* Chrom. | 415 | 1,009 | 352 | 1,519 | 695 | 6,052 | 451 |
| *n* Leth. | 11 | 41 | 23 | 105 | 64 | 566 | 40 |
| Per cent leth. | 2·65 | 4·06 | 6·53 | 6·91 | 9·21 | 9·35 | 8·87 |
| **Second broods** | | | | | | | |
| *n* Chrom. | 330 | 1,312 | 440 | 1,451 | 910 | 4,714 | 493 |
| *n* Leth. | 5 | 28 | 11 | 84 | 45 | 214 | 11 |
| Per cent leth. | 1·52 | 2·13 | 2·50 | 5·79 | 4·95 | 4·54 | 2·23 |
| **Third broods** | | | | | | | |
| *n* Chrom. | | 268 | | | 265 | | |
| *n* Leth. | | 2 | | | 7 | | |
| Per cent leth. | | 0·74 | | | 2·64 | | |

*n* Chrom. = total number of chromosomes examined.
*n* Leth. = number of lethal chromosomes.
Per cent leth. = percentage of sex-linked recessive lethal mutations.

Table 2. The Anti-mutagenic Effect of Adenine towards Formaldehyde at Different Concentrations of Formaldehyde

| Molarity of adenine | $6{\cdot}6 \times 10^{-3}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Molarity of formaldehyde | $0{\cdot}5 \times 10^{-3}$ | $1{\cdot}0 \times 10^{-3}$ | $1{\cdot}5 \times 10^{-3}$ | $2{\cdot}0 \times 10^{-3}$ | $3{\cdot}0 \times 10^{-3}$ | $4{\cdot}0 \times 10^{-3}$ | $5{\cdot}0 \times 10^{-3}$ |
| | | | First broods | | | | |
| n Chrom. | 676 | 1,461 | 1,363 | 1,231 | 1,027 | 869 | 909 |
| n Leth. | 5 | 35 | 57 | 46 | 43 | 34 | 35 |
| Per cent leth. | 0·74 | 2·39 | 4·18 | 3·74 | 4·18 | 3·91 | 3·85 |
| | | | Second broods | | | | |
| n Chrom. | 243 | 756 | 528 | 546 | 251 | 382 | 795 |
| n Leth. | 2 | 11 | 14 | 16 | 6 | 11 | 22 |
| Per cent leth. | 0·82 | 1·45 | 2·65 | 2·93 | 2·39 | 2·88 | 2·77 |
| | | | Third broods | | | | |
| n Chrom. | | 371 | | | 263 | | |
| n Leth. | | 0 | | | 4 | | |
| Per cent leth. | | 0·00 | | | 1·52 | | |

n Chrom. = total number of chromosomes examined.
n Leth. = number of lethal chromosomes.
Per cent leth. = percentage of sex-linked recessive lethal mutations.

aldehyde for all concentrations above approximately $1{\cdot}5 \times 10^{-3}$ *M* formaldehyde is seen to be depressed down to the level postulated. The second brood follows essentially the same pattern, but is depressed lower than in the first brood; this may be because the normal brood gradients for the mutagenic activity of formaldehyde (curves *a* and *b*) involve different levels of purine synthesis, so that, in effect, adenine is able to depress purine synthesis more effectively in the second brood. At concentrations of formaldehyde below $1{\cdot}5 \times 10^{-3}$ *M*, the anti-mutagenic effect of adenine in both broods is much less apparent, and here may be accounted for simply by removal of formaldehyde by chemical combination with adenine. Third broods were sampled at $1{\cdot}0 \times 10^{-3}$ *M* and $3{\cdot}0 \times 10^{-3}$ *M* formaldehyde. Usually, the mutation-rate has returned to the spontaneous level by the third brood, but as can be seen from Tables 1 and 2, some mutagenic activity is still detectable. A slight anti-mutagenic trend can also be observed here.

As previously reported[1], the anti-mutagenic activity of adenine towards formaldehyde is conditional on the strain (and concentration) of yeast employed in the culture medium. The present communication describes a further case of conditional anti-mutagenesis; namely, the concentration of the mutagen at which anti-mutagenic activity is tested.

I wish to acknowledge financial support from the Medical Research Council, under the auspices of which this work was carried out.

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# FRACTIONATION OF CELL SUSPENSIONS IN AN ELECTROMAGNETIC FORCE FIELD

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THE effectiveness of centrifugation as a method of fractionation of aqueous suspensions of cells and of cell debris is limited by the fact that the densities of these biological materials differ but little from each other and from the density of the suspension fluid. The effective electrical conductivities of cells, on the other hand, vary widely, sometimes by two or three orders of magnitude. A method of fractionation based on differences in electrical conductivites, rather than in densities, of suspended particles would therefore be of interest. The possibility of developing such a method is suggested by an effect recently described by one of us[1]. It has been shown that a spherical particle of conductivity $\sigma'$ suspended in a fluid of conductivity $\sigma''$ experiences a force when a homogeneous current is passed through the suspension across which a homogeneous magnetic field is maintained preferably at right angles to the current. The force is perpendicular to the magnetic field and the current and is given by the expression:

$$\mathbf{F} = \frac{3}{2} V \left( \frac{\sigma'' - \sigma'}{2\sigma'' + \sigma'} \right) [\mathbf{J} \times \mathbf{B}] \qquad (1)$$

where $V$ is the volume of the sphere, **J** the current density and **B** the magnetic flux density[2]. This force is seen to vanish for $\sigma'' = \sigma'$ and to reverse direction for $\sigma' > \sigma''$.

The velocity of a spherical particle of radius $R$ in a fluid of viscosity $\eta$ is given by the expression:

$$v = \frac{R^2}{3\eta} \left( \frac{\sigma'' - \sigma'}{2\sigma'' + \sigma'} \right) [\mathbf{J} \times \mathbf{B}] \qquad (2)$$

This equation suggests the possibility of separating particles on the basis of differences in $R$ and in $\sigma'$.

To obtain unidirectional migration, it is not necessary to use unidirectional currents and constant magnetic fields. This result may be also obtained by using alternating magnetic fields and currents in

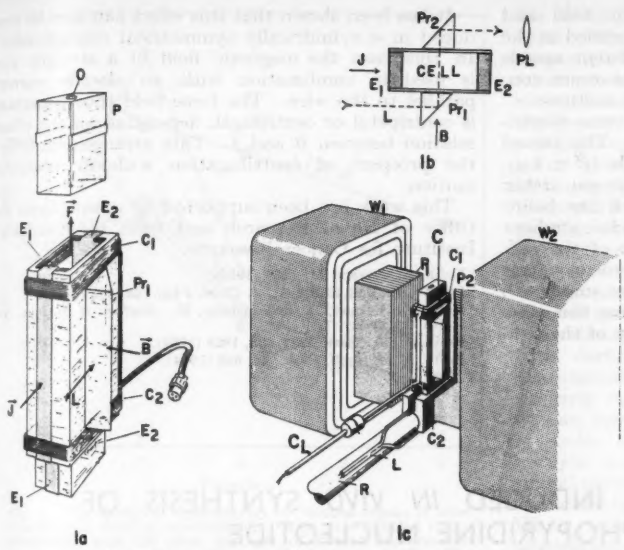


Fig. 1*a*. Migration cell: $E_1, E_2$, electrodes; $Pr_1$, prism; $C_1, C_2$, coils; $L$, illuminating light beam; $J$, current density vector; $B$, magnetic field vector; $F$, force vector; $P$, plug; $O$, overflow channel

Fig. 1*b*. Light path $L$ (indicated by broken line): $E_1, E_2$, electrodes; $Pr_1$ and $Pr_2$, prisms; $J$, current density vector; $B$, magnetic field vector; $PL$, projection lens

Fig. 1*c*. Migration cell in the magnetic field: $W_1$ and $W_2$, magnet coils; $P_1$ and $P_2$, pole pieces ($P_2$ is depicted cut-away to show the cell); $C$, migration cell; $C_1$ and $C_2$, adjustment coils; $R$, support rod; $L$, electrode lead wires; $CL$, lead wires for coils $C_1$, $C_2$

phase. The use of alternating currents greatly simplifies the design of the migration cell which is shown in Fig. 1*a*. The current **J** is passed between the parallel metal electrodes $E_1$, $E_2$. The other two parallel walls of the migration channel of the cell are made of 'Lucite'. Light enters the migration channel after reflexion inside the prism $Pr_1$. It traverses the cell parallel to the magnetic field vector $B$ and hits a prism $Pr_2$ (shown in Fig. 1*b*) mounted parallel to $Pr_1$ on the opposite side of the cell. The 45 deg. surface of $Pr_2$ is oriented so as to reflect the light parallel to and in the same direction as $L_1$. A projection lens $PL$ located beyond $Pr_2$ (Fig. 1*b*) forms an image of the interior of the migration channel on a distant screen. Fig. 1*c* shows the cell placed between the pole pieces $P_1$ and $P_2$ of the magnet. The plug $P$, shown above the cell in Fig. 1*a*, is inserted into the migration channel after the cell is filled. This plug is provided with a narrow channel $O$ for escape of surplus liquid. The vector **F** indicates the direction of the force exerted upon the suspended particles for $\sigma' > \sigma''$ and, hence, the direction of migration. $C_1$ and $C_2$ (Fig. 1*a*) are coils wound about the migration cell. They facilitate adjustment of the cell at right angles to the magnetic field. When the cell is properly oriented the electromotive force induced in the coils $C_1$ and $C_2$ vanishes.

Two experimental difficulties must be eliminated before successful fractionation of suspensions can be accomplished: (1) the thermal convection caused by a horizontal temperature gradient established by passage of a current through the cell must be eliminated; and (2) the electromagnetic convection[3] caused by non-uniformities in the magnetic field and/or in the current density distribution in the fluid column must be suppressed. The horizontal temperature gradient is associated with a horizontal density gradient which upsets the gravitational equilibrium in the fluid column. The effect produced by a non-uniformity in the magnitude of $[\mathbf{J} \times \mathbf{B}]$ at right angles to the **F**-axis is analogous, since the force density $\mathbf{f} = [\mathbf{J} \times \mathbf{B}]$ is the counterpart of the weight density in the case of gravitational equilibrium.

Both types of convection can be effectively inhibited by establishing a steep density gradient in the migration column. This device has been previously used successfully for suppression of thermal convection in electrophoresis[4]. An adequate density gradient can be produced by filling the lower half of the cell with a 5 per cent solution of sodium chloride containing 46 gm. of sucrose per 100 ml. of solution and the upper half with 1·3 per cent sodium chloride solution. The density gradient is established by stirring the liquid column.

A droplet of the suspension to be fractionated is now injected into the density gradient. It settles at the density-level corresponding to its own density. Fluid is then withdrawn from this level by micropipette to create a density discontinuity. A small amount of the suspension (the density of which is adjusted to the value of the density of the withdrawn fluid) is now carefully injected at the level of the density jump so as to create a thin sharp zone. The conductivity of the suspension is adjusted approximately to the value of the conductivity of the density

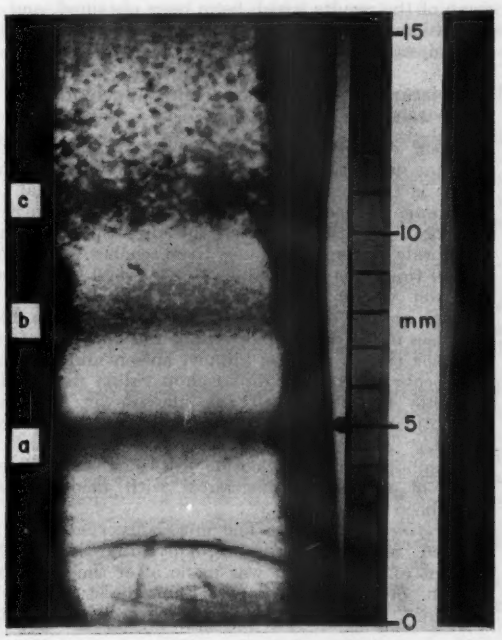


Fig. 2. Fractionation pattern obtained in 2 min.: (*a*) red blood cells; (*b*) lycopodium spores; (*c*) sea urchin eggs

gradient column. When the magnetic field and current are turned on, the particles suspended in the initial zone begin to migrate with different speeds and the zone finally splits into separate zones containing the different components of the mixture.

Fig. 2 shows a fractionation which was accomplished within approximately 2 min. The mixed suspension contained (*a*) red blood cells ($R \simeq 4\,\mu$), (*b*) lycopodium spores ($R \simeq 15\,\mu$) and (*c*) sea urchin eggs ($R \simeq 60\,\mu$). The thin curved black line below the *a*-zone depicts a steep refractive index gradient formed by convection near the bottom of the cell. The magnetic field $\mathbf{B} \simeq 6{,}000$ gauss (root mean square value) and the current density $\mathbf{J} \simeq 100$ m.amp./cm.$^2$. The temperature rise in the liquid during this time amounted to $\Delta t \simeq 5°$ C. The frequency of the field used was 60 c./s.

It has been shown that this effect can also be produced in a cylindrically symmetrical configuration[5]. In this case the magnetic field of a straight wire is used in combination with an electric current parallel to the wire. The force field thus generated is centripetal or centrifugal, depending on the phase relation between **B** and **J**. This arrangement offers the prospect of centrifugation without rotational motion.

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# SIGNIFICANCE OF INDUCED *IN VIVO* SYNTHESIS OF DIPHOSPHOPYRIDINE NUCLEOTIDE

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THE observation that the injection of nicotinamide into mice can produce large increases in the amount of diphosphopyridine nucleotide in the liver[1] has facilitated the *in vivo* study of many interesting biochemical problems. A description of some of the results which have been obtained, and a discussion of possible further applications of this system, are presented here.

## Nature of Diphosphopyridine Nucleotide Synthesis

*Extent of synthesis.* The increase in diphosphopyridine nucleotide following the injection of nicotinamide is temporary, and is roughly proportional to the dosage of nicotinamide up to a level of 500 mgm. per kgm. With this dose the diphosphopyridine nucleotide content of mouse liver reaches a level of 8 – 10 times the base value of 400 – 500 μgm. per gm. wet weight at about 10 hr., then returns to normal at the end of 24 hr. Two- to three-fold increases in the diphosphopyridine nucleotide content of other tissues such as kidney, spleen and tumour also occur. Oxidized diphosphopyridine nucleotide accounts for almost all the increase in pyridine nucleotides following the administration of nicotinamide. Attempts to show an accumulation of diphosphopyridine nucleotide by incubating liver slices or fortified homogenates with nicotinamide have been unsuccessful.

*Pyridine precursors.* The initial observation of a marked increase in diphosphopyridine nucleotide content of mouse liver was made after the administration of the nicotinamide antagonist 3-acetylpyridine[2]. When similar results were obtained with nicotinamide it became clear that acetylpyridine was being converted to nicotinamide *in vivo*. The conversion of an anti-metabolite to a metabolite in this instance can be considered as a type of detoxification mechanism.

A number of other pyridine derivatives, such as β-picoline, can also act as precursors of diphosphopyridine nucleotide in the whole animal[3]. The effectiveness of these compounds in producing synthesis of diphosphopyridine nucleotide can be correlated with their ability to replace nicotinamide in the diet of the duckling[4]. Of special interest is the observation that nicotinic acid is much less effective than nicotinamide as a precursor, and can even inhibit the conversion of nicotinamide to diphosphopyridine nucleotide[3].

*Effect of diphosphopyridine nucleotide synthesis on the chemical composition of mouse liver.* The biosynthesis of diphosphopyridine nucleotide stimulated by nicotinamide is reflected as an increase in the

Table 1. Change in some Acid-Soluble Constituents of Mouse Liver following the Administration of Nicotinamide

| | μmoles per gm. wet weight | |
|---|---|---|
| | Control | Nicotinamide injected |
| Diphosphopyridine nucleotide | 0·79 | 5·74 |
| Total nicotinamide | 0·73 | 5·99 |
| Adenine | 3·8 | 8·4 |
| Ribose | 12·9 | 20·4 |
| Total phosphate | 48·2 | 59·4 |

Analyses were carried out on a 5 per cent trichloracetic acid extract prepared from the livers of mice killed 8 hr. after the administration of 500 mgm. per kgm. of nicotinamide. Controls were injected with saline. Adenine was determined by the colorimetric method of Woodhouse (ref. 5), which gave results in good agreement with values calculated from the increase in optical density at 260 mμ (ref. 1). Total nicotinamide was determined by the Holman method (ref. 6) after boiling at 100° for 30 min. (pH 7·8). The values represent the pooled samples of four mice in each group.

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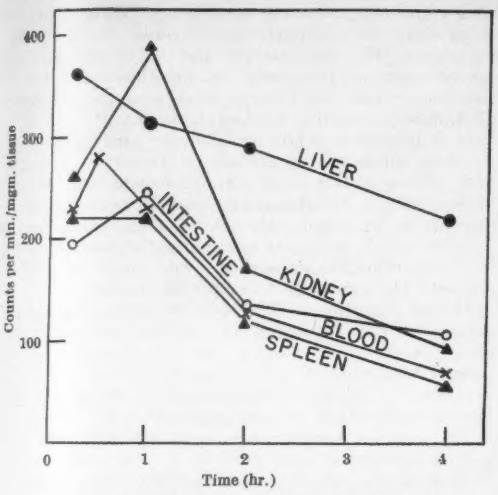


Fig. 1. The uptake of radioactivity by various organs of mice injected with labelled nicotinamide. Mice were injected intraperitoneally with 500 mgm. per kgm. of labelled nicotinamide (approximately $8 \times 10^8$ counts per minute per animal). The values for blood are counts per minute per 0·001 ml. whole blood. Radioactivity in other tissues was determined after dissolving the organs in boiling formamide

total acid-soluble nicotinamide, adenine, ribose and organic phosphate of mouse liver (Table 1). These changes are in good agreement with the increase in diphosphopyridine nucleotide. No change in adenosine phosphates or nucleic acid content of the liver has been detected.

These observations indicate that formation of diphosphopyridine nucleotide does not occur at the expense of adenine, ribose and phosphate already present in the liver. Rather, there must be either mobilization from extra-hepatic sources, or actual net synthesis of the required moieties.

## Incorporation of Labelled Precursors

*Incorporation of nicotinamide.* This system has provided an unusual opportunity for detecting intermediates in the conversion of nicotinamide to diphosphopyridine nucleotide under *in vivo* conditions. The specific activities of some mouse tissues following the injection of nicotinamide labelled at its carboxyl group with carbon-14 are shown in Fig. 1. The relatively constant level of radioactivity in the liver while rapid synthesis of diphosphopyridine nucleotide is taking place suggests the presence of precursors. One of the radioactive compounds detected in the liver early in the synthesis has been identified as free nicotinamide. Another has been identified as the nicotinic acid analogue of diphosphopyridine nucleotide[7]. Forty-five minutes after the injection of labelled nicotinamide the specific activity of the analogue was twice as high as that of diphosphopyridine nucleotide. The analogue is present in the liver in largest amounts during the time the diphosphopyridine nucleotide is being synthesized, and in small amounts during the subsequent period of diphosphopyridine nucleotide degradation. These observations[8] indicate that the nicotinic acid analogue or possibly a labile carboxyl derivative of the analogue is an intermediate of the synthesis of diphosphopyridine nucleotide from nicotinamide. Preiss and Handler[9] have shown that the analogue is an intermediate in the *in vitro* synthesis from nicotinic acid by erythrocytes. Nicotinamide is a relatively inefficient precursor, the principal product formed being nicotinamide mononucleotide. In the whole mouse, however, nicotinic acid is a poor precursor, and an inhibitor of the formation from nicotinamide of both analogue and diphosphopyridine nucleotide. Removal of the amide group already present in nicotinamide during its conversion to diphosphopyridine nucleotide might indicate a requirement for a carboxyl substituted pyridine nucleotide as an intermediate at some step in the synthesis.

*Incorporation of glucose.* Evidence for an accelerated conversion of glucose to ribose during the biosynthesis of diphosphopyridine nucleotide has been obtained in experiments where glucose labelled with carbon-14 was administered together with nicotinamide[10]. The incorporation of ribose labelled similarly was also stimulated by nicotinamide. There was an increase in the specific activity of the ribose of both diphosphopyridine nucleotide and free adenylic acid. Incorporation into the nicotinamide ribose moiety of diphosphopyridine nucleotide was considerably greater than into the adenine ribose. When labelled glucose alone was administered, incorporation into the nicotinamide ribose of the endogenous diphosphopyridine nucleotide was also greater than into the adenine ribose, indicating a more rapid turnover of the nicotinamide ribose than the adenine ribose in the normal animal. As yet it is difficult to explain these results in terms of known enzymatic mechanisms.

The rapid conversion of glucose to ribose during the induced biosynthesis of diphosphopyridine nucleotide makes this system useful for studying pentose formation in the whole animal. Experiments in which differentially labelled glucose was administered with nicotinamide[11] have shown that in mouse liver not more than 5 – 10 per cent of the diphosphopyridine nucleotide ribose is formed by oxidative decarboxylation and that pentose synthesis can be explained largely in terms of the transaldolase–transketolase pathway[12].

*Incorporation of phosphate.* Administration of nicotinamide at 500 mgm. per kgm. stimulated fourfold the incorporation of inorganic phosphate labelled with phosphorus-32 into the diphosphopyridine nucleotide of mouse liver[6]. In contrast to the results with labelled glucose, there was no preferential incorporation into the nicotinamide phosphate of diphosphopyridine nucleotide.

*Incorporation of adenine and its precursors.* Nicotinamide administration stimulated slightly the incorporation of adenine-8-$^{14}$C into diphosphopyridine nucleotide without affecting incorporation into free adenylic acid. The incorporation of both glycine-2-$^{14}$C and formate-$^{14}$C into diphosphopyridine nucleotide, free adenylic and nucleic acid adenine was stimulated as much as five- to ten-fold by nicotinamide when incorporation was measured over a 1-hr. interval. When formate incorporation was measured over a 5-min. interval there was a fifteen-fold increase in specific activity of free adenylic acid but little change in the labelling of diphosphopyridine nucleotide. Nicotinamide had no effect on the incorporation of formate-$^{14}$C or glycine-2-$^{14}$C into liver protein.

When incorporation of formate, glycine, glucose and adenine was measured over successive half-hour intervals following injection of nicotinamide, the total incorporation of formate into diphosphopyridine nucleotide was found to increase, while the incor-

poration of other precursors either decreased or showed little change. This may indicate the occurrence of some exchange reactions.

The observation that the administration of nicotinamide can increase the incorporation of glucose, formate and glycine into free adenylic acid as well as into diphosphopyridine nucleotide suggests that there is actually a net synthesis of adenine and ribose rather than a transfer of these components into the liver for diphosphopyridine nucleotide synthesis. This should make the system synthesizing diphosphopyridine nucleotide useful for studying net purine synthesis over a short time period in the intact animal.

## Metabolic Studies with altered *in vivo* Levels of Diphosphopyridine Nucleotide

Few studies of the effect of an elevated level of diphosphopyridine nucleotide in the liver on metabolism have yet been carried out. Smith *et al.*[13] have examined the effect of nicotinamide administration on ethanol metabolism in the whole mouse, in liver slices and in liver homogenates. The only difference observed was a two-fold increase in the rate of ethanol oxidation by liver homogenates prepared in a medium containing nicotinamide. They concluded that normal diphosphopyridine nucleotide-levels are adequate for ethanol oxidation in the whole animal or in liver slices, the limiting factor being enzyme concentration. In homogenates, where considerable destruction of endogenous diphosphopyridine nucleotide takes place by enzymes released from the tissue, increasing the diphosphopyridine nucleotide-content of the intact liver may help to maintain normal levels. We have found that the oxidation of formate-$^{14}$C to carbon dioxide in the whole mouse is also unaffected by nicotinamide administration.

## Some Factors influencing Diphosphopyridine Nucleotide Synthesis

*Effect of tumour growth.* Waravdekar *et al.*[14] have reported that the growth of tumours in mice causes a decrease in the diphosphopyridine nucleotide content and diphosphopyridine nucleotide pyrophosphorylase activity of the blood. We have observed a 50 per cent reduction in the synthesis of diphosphopyridine nucleotide induced by nicotinamide (on a unit wet-weight basis) in the livers of mice bearing advanced leukæmia *L*-1210. This apparently reflected leukæmic infiltration and could be correlated with an increase in liver weight. There was actually little change in the amount of diphosphopyridine nucleotide synthesized per mouse. Treatment with amethopterin, which restored liver weights to normal, also restored synthesis. The growth of a number of solid tumours was found to have little effect on diphosphopyridine nucleotide synthesis in the liver.

*Nicotinamide antagonists.* These can affect the *in vivo* synthesis of diphosphopyridine nucleotide from nicotinamide in a number of different ways. Some pyridine derivatives, for example 3-acetylpyridine, are converted to nicotinamide in the body[2,3] and are capable of increasing the synthesis at low doses, or inhibiting it at high doses[3].

The effect on diphosphopyridine nucleotide synthesis of the nicotinamide antagonist 2-ethylamino-1,3,4-thiadiazole depends on the dose of nicotinamide. Inhibition was evident when the thiadiazole was administered with a high dose of nicotinamide, but with a low dose there was stimulation. These relationships may be of particular interest because the toxicity of the thiadiazoles and their anti-tumour activity can be prevented by nicotinamide[15,16] and thiadiazole can be incorporated into an analogue of diphosphopyridine nucleotide *in vitro*[16].

It is difficult to relate interference with diphosphopyridine nucleotide synthesis to toxicity. A single dose of one of the most potent nicotinamide antagonists, 6-amino nicotinamide, was not found to have any effect on this synthesis[3]. On the other hand, nicotinic acid, which is not generally considered to be a nicotinamide antagonist, was found to inhibit strongly the synthesis from nicotinamide[3].

*Purine antagonists.* The toxicity and antileukæmic action of 6-mercaptopurine can be prevented by administration of adenylic acid or a number of related compounds[17]. Diphosphopyridine nucleotide synthesis in mice is inhibited by 6-mercaptopurine and this inhibition can also be prevented by adenylic acid[1]. Similar results have been obtained with the purine antagonist thioguanine. In addition to decreasing the amount of diphosphopyridine nucleotide synthesized, these compounds also appear to interfere with the return of its levels to normal values at the end of 24 hr. following nicotinamide administration. In the case of 6-mercaptopurine this difference at 24 hr. can be as much as five-fold, and this effect of the drug is not reversed by adenylic acid[1].

*Folic acid antagonists.* The toxicity and antileukæmic action of aminopterin and amethopterin can be prevented by folic acid or some of its derivatives[18]. The folic acid antagonists are presumed to inhibit tumour growth by interfering with the biosynthesis of nucleic acids. Skipper *et al.* have reported decreased incorporation of formate-$^{14}$C into the nucleic acid purines of mice after treatment with aminopterin or amethopterin[19]. There have also been reports that such treatments actually stimulate *in vivo* incorporation of formate[20].

Amethopterin was found to have little effect on either the normal levels of diphosphopyridine nucleotide or upon *in vivo* synthesis following nicotinamide injection, even after extensive treatment. Similarly, experiments with mice bearing leukæmia *L*-1210 showed that this tumour retained its ability to synthesize diphosphopyridine nucleotide even while undergoing definite regression in size as a result of amethopterin treatment.

The incorporation of formate-$^{14}$C into mouse-liver diphosphopyridine nucleotide was found to be stimulated as much as eight-fold by treatment with amethopterin. Increased formate incorporation could be correlated with signs of toxicity such as weight loss, decreased leucocyte count and mortality. On a schedule of single daily treatments there was almost direct proportionality between the dose of amethopterin and formate incorporation (Fig. 2).

Increased formate incorporation into liver adenylic acid, nucleic acids and protein after amethopterin treatment could also be demonstrated when no nicotinamide was given. These observations may be related to the results reported by Barclay and Garfinkel[21]. They found that the incorporation of formate-$^{14}$C into liver proteins and nucleic acids was stimulated by treatment with N-methyl formamide, carbon tetrachloride or azaserine. They interpret this effect as a manifestation of hepatotoxicity.

*Tranquillizing agents.* The administration to mice of reserpine or promazine before the injection of

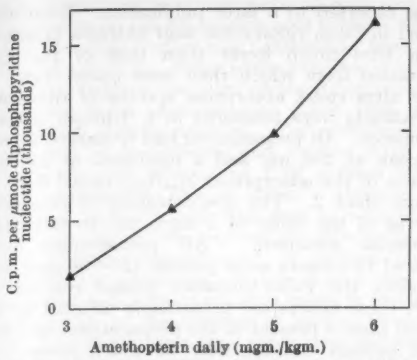


Fig. 2. Effect of daily treatment with amethopterin on the incorporation of formate-$^{14}$C into the diphosphopyridine nucleotide of mouse liver. Mice received daily subcutaneous injections of amethopterin for seven days. On the eighth day they were injected with 500 mgm. per kgm. of nicotinamide and formate-$^{14}$C. After 6 hr. the livers were homogenized with trichloracetic acid and the diphosphopyridine nucleotide isolated by ion-exchange chromatography

500 mgm. per kgm. of nicotinamide has little effect on the resulting increase in liver diphosphopyridine nucleotide, but prevents the return of its levels to normal at the end of 24 hr.[22]. High concentrations in the liver will then persist for as long as 48 hr. following the injection of nicotinamide. Whether this phenomenon results from some specific action upon the mechanisms which regulate the normal levels has yet to be resolved. When a number of reserpine derivatives were tested there was good correlation between their tranquillizing and anti-leukæmic effectiveness[23] and their ability to maintain the elevated level of diphosphopyridine nucleotide of liver following nicotinamide administration.

It is also of interest that reserpine will stimulate as much as ten-fold the incorporation of formate into the acid-soluble adenine of mouse liver. Such treatment has no effect on glycine incorporation or on the incorporation of formate into liver protein.

The investigations described here represent a few of the many fruitful ways in which diphosphopyridine nucleotide synthesis can be used to study biochemical mechanisms and the action of drugs in the whole animal.

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# AN INFECTIVE 'RIBONUCLEIC ACID' COMPONENT FROM TUMOUR CELLS INFECTED WITH ENCEPHALOMYOCARDITIS VIRUS

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TREATMENT of tobacco mosaic virus with cold phenol gives preparations having up to 1 per cent of the original infectivity[1,2]; these are rich in ribonucleic acid, but contain too little virus protein to account for their infectivity. Since they are, moreover, highly unstable and can be rapidly inactivated by ribonuclease, it has been suggested that their infectivity is a property of ribonucleic acid released from the virus by phenol treatment[3], although this conclusion has been criticized on chemical grounds[3]. Phenol extracts of cells and tissues infected by several animal viruses have been shown to possess infectivity[4–6]. However, it is not clear (1) that the low infectivity is not due to residual intact virus; (2) that the infective material in phenol extracts comes from virus as such, and not from some other component of the infected tissue; or (3) that the infectivity is due to virus ribonucleic acid. Phenol extracts of infected cells will contain so much cellular ribonucleic acid that a minor non-ribonucleic acid component with virus activity might well escape detection.

We have been working with an *in vitro* and *in vivo* animal virus/host-cell system which may help to answer these questions. The first results reported here suggest that the infective material found in the aqueous phase following phenol extraction has properties which distinguish it from normal virus. Moreover, this material appears to come from some component of the infected tissue other than the virus itself.

Murine encephalomyocarditis virus is able to multiply to high titre in cells of the Krebs 2 mouse ascites carcinoma, maintained *in vitro* as continuously agitated cell suspensions[7]. With multiple infection (cells $10^7$/ml.; virus $3 \times 10^7$/ml.) new virus first appears intracellularly about 4 hr. after infection, and reaches a maximum at 8 hr. Release of virus from a population of infected cells, beginning at 6–7 hr. after infection, occurs at a maximum rate between 9 and 11 hr. after infection, and is complete by 12 hr. The supernatant fluid then contains[8] about $1 \times 10^9$ plaque-forming units of virus per ml., and the same number of mouse $ID_{50}$ when titrated *in vivo*.

Phenol extracts made either from culture fluids harvested at the peak of virus release (12–14 hr.), or from infected cells at various stages of the growth cycle, have demonstrable infectivity. Extractions were carried out at 4° C. by the method of Schuster *et al.*[9], and the preparations—henceforth termed 'ribonucleic acid extracts'—stored at − 70° C. Their infectivity for Krebs 2 carcinoma cells was tested in two different ways. (1) The ability of the material to infect static, non-dividing cells was tested by a plaque method of titration, using tumour cells suspended in agar[8]. (2) The activity of the material in a population of growing cells was tested by mixing it with suspensions of tumour cells, and injecting samples of $10^7$ cells intraperitoneally into each of five mice per dilution. The encephalomyocarditis infectivity end-point was calculated by standard methods.

Table 1

| Starting material | Virus content of starting material (plaque-forming units/ml.) | Infectivity of ribonucleic acid extract | |
|---|---|---|---|
| | | By plating (plaque-forming units/ml.) | By mouse titration ($MID_{50}$/ml.)* |
| Supernatant from 14-hr. infected culture | $2 \times 10^9$ | 45 | $4 \times 10^4$ |
| | | 50 | $3 \times 10^4$ |
| | | 30† | $6 \times 10^3$ |
| | | 20† | $1 \times 10^3$ |
| | | 400 | $5 \times 10^4$ |
| | | 600 | $3 \times 10^4$ |
| Infected cells | | | |
| 2 hr. | $1 \times 10^8$ | 5 | 10 |
| 4 hr. | $2{\cdot}8 \times 10^7$ | 125 | $5 \times 10^3$ |
| 8 hr. | $2{\cdot}2 \times 10^8$ | 95 | $3 \times 10^3$ |

* $MID_{50}$/ml., mouse infective doses/ml.
† Ethanol precipitated preparation.

Ribonucleic acid extracts made in the way described contained 5–600 plaque-forming units/ml. when plated on Krebs 2 cells (Table 1). The plaques formed appeared identical with those of the parent virus, and virus re-isolated from them had the expected properties. However, the plaque count for ribonucleic acid extracts in general did not diminish linearly with dilution, as already noted for eastern equine encephalomyelitis virus[8]. Plaque titration appears to measure the number of cells in the cell suspension used for titration which are 'competent' to take up active material from the ribonucleic acid extracts and make virus from it, rather than to estimate the total number of infective fragments present in the extract. This is borne out by the much higher titre shown by ribonucleic acid extracts when they are mixed with cells and titrated in mice (Table 1). Presumably a much higher proportion of cells become 'competent' under these conditions and are consequently able to produce virus. Further investigations of this cellular competence phenomenon will be reported in a later publication. Even when titrated in mice, ribonucleic acid extracts invariably had a titre much lower than that of the virus preparation from which they were made (Table 1).

The ultra-violet absorption spectra of ribonucleic acid extracts were measured in a 'Unicam' spectrophotometer. All preparations had a marked absorption peak at 260 mμ and a minimum at 240 mμ; the ratio of the adsorptions $\lambda_{260}/\lambda_{280}$ varied from 1·6 to more than 2. The concentration of ribonucleic acid was of the order of 2 mgm./ml. in terms of a commercial standard. All preparations tested appeared to contain some protein (20–150 μgm./ml.), but, since the Folin–Ciocalteu phenol reagent was used[10], these figures are presumably affected by any residual phenol present in the preparations, and their actual protein content may be much lower. All preparations, however, contained an enormous excess of cellular nucleic acid, mostly unrelated to the virus, so that chemical methods could not be used to show that the infectivity found belonged to viral ribonucleic acid alone and not to traces of other materials.

The infective material present in phenol extracts was, however, unlikely to be residual virus which had somehow escaped the inactivating effect of phenol. The infectivity of phenol extracts of mengo encephalitis and eastern equine encephalomyelitis viruses is destroyed by ribonuclease, and by incubation at 37° C., both treatments having relatively little effect on intact virus[4–6]. The infectivity of phenol extracts, moreover, can be precipitated with ethanol or 1 *M* sodium chloride, while that of virus is not so precipitated[5,6]. However, in some of the experiments already reported[4,6], the virus and ribonucleic acid preparations were not compared at equivalent levels of infectivity. Moreover, a possible 'protective' effect on virus of the large excess of normal cell ribonucleic acid in the phenol extract has not been considered. We have therefore tried to make comparison between an infective ribonucleic acid extract and encephalomyocarditis virus under as similar conditions as possible. Results are given in Table 2.

A phenol extract has been compared with encephalomyocarditis virus diluted to give a comparable plaque count; sufficient of a phenol extract of uninfected cells was added to the latter to give both preparations the same ultra-violet absorption at 260 mμ. Treatment with ribonuclease (10 μgm./ml.)

Table 2. Comparison of Properties of Infective Ribonucleic Acid and Encephalomyocarditis Virus

| Sample | Ribonucleic acid extract ($MID_{50}$/ml.) | Encephalomyocarditis virus ($MID_{50}$/ml.) |
|---|---|---|
| Control | $3 \times 10^3$ | $1 \times 10^3$ |
| After ribonuclease | 0 | $2{\cdot}5 \times 10^3$ |
| After 1 hr. at 37° C. | 10 | $7 \times 10^2$ |
| After 1 hr. at 37° C. + 5 per cent rabbit serum | 10 | $5 \times 10^3$ |
| After 1 hr. at 37° C. + 0·1 per cent bovine plasma albumin | 10 | $7 \times 10^2$ |
| Sediment from ethanol precipitation (3 ×) | $7 \times 10^3$ | 30 |
| Sediment from precipitation with 1 *M* NaCl (3 ×) | $1{\cdot}6 \times 10^3$ | 70 |
| | Ribonucleic acid extract (plaque-forming units/ml.) | Encephalomyocarditis virus (plaque-forming units/ml.) |
| Plating on normal cells (1) | 20 | 120 |
| (2) | 20 | |
| Plating on irradiated cells (1) | $7 \times 10^2$ | 110 |
| (2) | $3 \times 10^2$ | |

for 15 min. at room temperature completely destroyed the infectivity of the ribonucleic acid extract, whereas that of the virus control was unaffected. Incubation at 37° C. for 1–1½ hr., either in the presence or absence of protein, reduces the titre of the ribonucleic acid preparation more than ten-fold, while that of the virus is only slightly affected. The ribonucleic acid extract can be precipitated and washed three times with 67 per cent ethanol or 1 *M* sodium chloride without significant loss of titre. However, the addition of 'carrier' ribonucleic acid to a dilute virus preparation also allows some of the infectivity to be carried through ethanol or 1 *M* sodium chloride precipitation; previously, it was found that both ethanol and 1 *M* sodium chloride failed to precipitate virus activity in the absence of carrier ribonucleic acid[5]. The above tests thus show that the material in ribonucleic acid extracts differs considerably from virus, particularly in its heat-lability and susceptibility to ribonuclease, but under our conditions precipitation by ethanol and molar salt cannot be held to show that the material is ribonucleic acid. Moreover, the biological activity of ribonucleic acid extracts differs from that of virus diluted to equivalent infectivity. First, there is the low titre shown by plating ribonucleic acid extracts compared with that shown by injection of the infected cells into mice (Table 1); encephalomyocarditis virus has the same titre both by plating and by mouse titration. Ribonucleic acid extracts and virus, diluted to a comparable level of infectivity, also behave differently when plated on Krebs 2 carcinoma cells which have been treated with ultra-violet light (cell concentration $10^7$/ml., lamp 15 watts, 61 cm. distance, 2 min. exposure with agitation). Pre-treatment of cells in this way can increase the apparent titre of a ribonucleic acid extract ten-fold, whereas that of virus is not affected (Table 2).

Simple washing with phosphate-buffered saline of cells which have been treated for 30 min. *in vitro* with ribonucleic acid or virus did not remove virus from the cells, but rendered cell/ribonucleic acid complexes non-infective. Finally, treatment of ribonucleic acid/cell complexes, after 30 min. at room temperature, with either encephalomyocarditis antisera, or inactivated horse serum, destroys the infectivity, a treatment which is without effect upon virus-infected cells.

The amount of infectivity extractable by phenol from infected cells is not directly related to their virus content (Table 1; cf. 'virus' and 'ribonucleic acid' infectivities of 4 and 8 hr. cell samples). This suggested that the infectivity of material extracted with phenol might come from some component other than the virus itself. An infected culture fluid ($5{\cdot}8 \times 10^8$ plaque-forming units/ml.) was therefore centrifuged for 1 hr. at 105,000 *g*, and the supernatant removed and saved. Ribonucleic acid extracts were made from the supernatant, the sediment re-suspended to volume, and the stock from which these materials were prepared. The results are shown in Table 3. Although the virus content of the supernatant fluid was only one-thousandth of that of the sediment, the ribonucleic acid extract of the supernatant had more than ten times the infectivity of that extracted from the sediment. Two other preparations showed that even the residual infectivity of the sediment is probably due to contamination by supernatant material. Virus from a stock containing $2 \times 10^9$ plaque-forming units/ml. was concentrated and washed twice by centrifuging at 105,000 *g*; the two preparations contained $3 \times 10^9$ and $5 \times 10^9$ plaque-forming units/ml., respectively. Phenol extracts showed no infectivity either by plating or by mouse test.

Table 3

| Sample | Virus content (plaque-forming units/ml.) | Infectivity of ribonucleic acid extract ($MID_{50}$/ml.) |
|---|---|---|
| Tissue culture fluid | $5{\cdot}8 \times 10^8$ | $6{\cdot}3 \times 10^3$ |
| (*a*) Supernatant from 1 hr. centrifuging at 100,000 *g* | $2{\cdot}2 \times 10^3$ | $3{\cdot}0 \times 10^3$ |
| (*b*) Sediment from 1 hr. centrifuging at 100,000 *g* | $1{\cdot}2 \times 10^8$ | $1{\cdot}6 \times 10^3$ |
| Sediment as in (*b*) washed (1) | $5 \times 10^8$ | 0 |
| 2 × by centrifuging for 1 hr. at 100,000 *g* (2) | $3 \times 10^3$ | 0 |

The infective material in phenol extracts may thus come from a component in the infected tissue which does not sediment to any extent under conditions which bring down virus. Treatment of infected cell homogenates with ribonuclease removes ultra-violet absorbing material without affecting the infectivity which can afterwards be extracted by phenol[6]. This indicates that the potentially infective material must normally be present intracellularly in a form resistant to the action of ribonuclease.

Ascites tumour cells infected with encephalomyocarditis virus, or the extracellular fluid into which virus has been released by the destruction of infected cells, thus contain, in addition to virus, a second component related in some way to virus synthesis. Phenol treatment breaks this material into fragments carrying the genetic information necessary for the production of virus. The origin and cellular location of this material and the part it plays in virus synthesis is at present wholly obscure. It could be a virus precursor, 'unpacked' viral genetic material incorporated in some cellular structure, or a form of viral ribonucleic acid which has failed to be assembled into complete virus.

When fragments enter competent cells, virus synthesis proceeds. The influence of such factors as ultra-violet light, injection into mice, etc., in inducing cellular competence may be best understood if we consider that virus infection has two distinct aspects. (1) Regarded as the most important until now, the production of new virus, which has been visualized essentially as the replication by the cell of a viral genetic pattern. (2) Since, immediately after virus infection, biosynthesis starts in the cell, we must postulate the existence of some stimulus which triggers the cell to synthesis. We can thus imagine that an infective virus particle carries both the genetic information and the trigger, while the material extracted with phenol carries the specific viral genetical information but lacks the trigger. In this case virus production will only occur when the cell is stimulated to synthesis by other means.


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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.*

## Crystal Structure of Rhombohedral Sulphur

The allotropic form of sulphur first discovered by Engel[1] has been variously termed Engel's sulphur, $S_\varepsilon$, $S_\rho$, $S_\varphi$, trigonal sulphur, and rhombohedral sulphur. The molecule was shown to be hexameric by Aten[2]. Friedel[3] found the crystals were hexagonal prisms terminated by a flat rhombohedron. Although these crystals are largely converted to a mixture of plastic and orthorhombic sulphur an hour or so after they have been exposed to air or X-rays, Frondel and Whitfield[4] were able to determine the hexagonal lattice constants, show that the symmetry axis was three-fold, and demonstrate the absence of vertical planes of symmetry; the lattice constants, combined with the observed density[1], give 18 sulphur atoms per unit cell. The quality of their photographs was such that they were unable to determine whether the lattice mode was hexagonal or rhombohedral. Their X-ray study, however, combined with the morphological observations, established the point group as $C_{3i}$–$\bar{3}$, and Donnay[5] later pointed out that on purely morphological grounds the lattice is rhombohedral and that the space group is thus probably $C_{3i}^{2}$–$R\bar{3}$ (No. 148).

By taking rotation and small oscillation-range Weissenberg photographs around $a$ and $c$, each with a different crystal, we have verified directly that the lattice is indeed rhombohedral. For the triply primitive hexagonal cell, we find the provisional values $a = 10{\cdot}83$ A. and $c = 4{\cdot}26$ A., in satisfactory agreement with Frondel and Whitfield's values of 10·9 kX. and 4·26 kX. The general position of $C_{3i}^{2}$–$R\bar{3}$ is six-fold; the primitive rhombohedral cell accordingly contains one molecule of $S_6$.

There are 31 unique ($hk.0$) reflexions accessible to $K\alpha$ copper radiation, and 25 of these have been observed. By the use of intensities estimated with the multiple film technique together with signs for the structure amplitudes obtained with the aid of a map of the molecular structure factor, we have prepared the projection of electron-density on (00.1), Fig. 1. The $x$ and $y$ parameters measured from this projection must be regarded as preliminary because neither series-termination effects nor errors due to absorption have been taken into account.

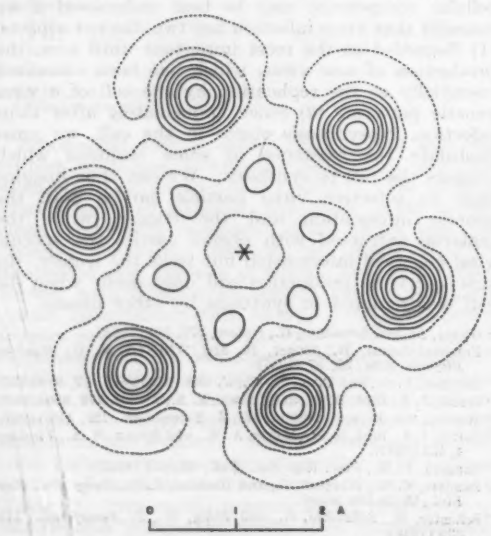


Fig. 1. Electron-density projected down the $c$-axis. Contours drawn at intervals of five electrons per A.$^2$ (zero contour dotted)

Our ($0k.l$) photographs are somewhat poorer in quality than our ($hk.0$) photographs. Qualitative intensity considerations suggest a value of the $z$ parameter of about 1/10. The fact that $z$ is not zero means that $S_6$ molecules are staggered rings with symmetry $D_{3d}$–$\bar{3}m$. The approximate bond-length is 2·0 A., the bond-angle about 100°. We expect to obtain more precise values for these and other angles and distances of interest when the structure has been more completely refined.

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## The Four Elastic Constants of Diamond

The thermal scattering of light in diamond has been studied in great detail by R. S. Krishnan[1] and by V. Chandrasekharan[2]. These authors pointed out that the frequency shifts observed for the Brillouin components are not in good agreement with the values calculated using the elastic constants data of Bhagavantam and Bhimasenachar[3]. The values of the elastic constants have since been determined by Prince and Wooster[4] and recently much more accurately by McSkimin and Bond[5]. McSkimin and Bond's values do not agree with those of Bhagavantam and Bhimasenachar and of Prince and Wooster, especially as regards $C_{12}$ and $C_{44}$. Using the values of McSkimin and Bond, the frequency shifts of the Brillouin components for the various orientations studied by Chandrasekharan with the bigger spectrograph were calculated, but the agreement with the experimental values was still unsatisfactory. We have therefore evaluated the elastic constants of diamond directly from the observed frequency shifts[6].

To achieve this, three values of the frequency shifts must be assumed. For convenience, the shifts of the longitudinal component arising from the elastic waves moving approximately along the direction [I44], which is inclined at about 10° to [011], and the longitudinal and transverse components of the elastic waves approximately along the direction [811], which is inclined at about 10° to [100], have been taken and, by a perturbation procedure[7], the elastic constants have been calculated. The values are $C'_{11} = 94{\cdot}9$, $C'_{12} = 15{\cdot}1$ and $C'_{44} = 52{\cdot}1 \times 10^{11}$. The accuracy is estimated to be 3–5 per cent, chiefly due to the errors possible in the angle of scattering. Using these elastic constants the effective elastic constants and the Brillouin shifts have been calculated for all the orientations and the results are given in Table 1.

Table 1*

| No. | Incident light along | Scattered light along | Elastic wave nearly along | Nature of wave | Effective elastic constant | | Brillouin shifts | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Exp. | Calc. | Exp. | Calc. |
| 1 | [2$\bar{1}$1] | [111] | [$\bar{1}$44] | long. | *108·2* | 107·8 | 8·56 | 8·55 |
| 2 | [2$\bar{1}$1] | [111] | [$\bar{1}$44] | trans. | 46·8 | 51·0<br>40·2 | 5·63 | 5·38<br>5·22 |
| 3 | [2$\bar{1}$1] | [$\bar{1}\bar{1}\bar{1}$] | [811] | long. | *96·6* | 96·6 | 8·09 | 8·09 |
| 4 | [2$\bar{1}$1] | [$\bar{1}\bar{1}\bar{1}$] | [811] | trans. | *51·1* | 51·9<br>50·7 | 5·88 | 5·93<br>5·86 |
| 5 | [2$\bar{1}$1] | [01$\bar{1}$] | [31$\bar{4}$] | long. | 106·7 | 107·4 | 8·50 | 8·53 |
| 6 | [2$\bar{1}$1] | [01$\bar{1}$] | [31$\bar{4}$] | trans. | 46·0 | 50·5<br>41·3 | 5·58 | 5·85<br>5·29 |
| 7 | [111] | [01$\bar{1}$] | [9 20 $\bar{2}$] | trans. | 46·2 | 51·8<br>41·3 | 5·59 | 5·92<br>5·29 |

* Values in italics were used in calculating the elastic constants.

Agreement between the experimental and the calculated values of the frequency shifts is very good. It must be mentioned that the exact directions of the hypersonic waves were used in the calculations. It is of interest to see that the observed frequency shifts of the transverse components (cases 2, 6 and 7) are midway between the theoretical values arising from the two transverse waves. Because of their closeness, they were recorded as unresolved.

The values of $C'_{12}$ and $C'_{44}$ obtained by us agree very well with those of McSkimin and Bond, but disagree with the earlier measurements. There seems to be some slight disagreement in $C'_{11}$.

The values of the elastic constants given by the various workers are collected in Table 2. They fall into two sets, namely, $C_{11}$, $C_{12}$, $C_{44}$ and $C'_{11}$, $C'_{12}$, $C'_{44}$.

(1) The values of $C_{11}$ and $C'_{11}$ for all workers agree closely, whereas $C_{12}$ and $C'_{12}$, $C_{44}$ and $C'_{44}$ disagree very considerably.

(2) The bulk modulus calculated on the basis $\varkappa = (C_{11} + 2C_{12})/3$ agrees well with the observed values, whereas, as already shown by McSkimin and Bond, the value $\varkappa = (C'_{11} + 2C'_{12})/3$ does not agree with the experimental value (column 7 of Table 2).

(3) The values of $(C_{12} + 2C_{44})$ and $(C'_{12} + 2C'_{44})$ are equal (column 6) irrespective of the method of measuring the elastic constants.

These three significant results indicate very clearly that the interpretation of the experiments must be in terms of the atomic theory of elasticity due to Laval[8] and Raman[9], as a consequence of the existence of non-central atomic forces. The elastic behaviour of cubic crystals belonging to $T_d$, $O$ and $O_h$ classes could be described only by four elastic constants $d_{11}$, $d_{12}$, $d_{44}$, $d_{45}$ and not by the usual three constants of Voigt's formulation. We designate the elastic constants obtained by using Christoffel's equation for the velocity of the linearly polarized plane waves in an infinite medium as the 'wave (dynamic) constants'. From the new theory of elasticity it is known that the values of the compressibility calculated using these constants will not agree with the observed value of the compressibility. Hence, we have identified the dashed quantities ($C'_{ij}$) in Table 2 as the 'wave (dynamic) constants'. In the pulse-phase comparison and thermal scattering methods the velocities are measured directly and hence the dashed constants are obtained. The undashed quantities ($C_{ij}$), on the other hand, can be designated as the 'static constants' because they agree with the compressibility data. The values of $C_{12}$ and $C_{44}$ obtained by Bhagavantam and Bhimasenachar fall in the latter (undashed) category. This may be due to the fact that although $C_{12}$ and $C_{44}$ have been calculated individually from the transverse wave equation, the torsional mode may have been excited in their experiments. It is not clear why Prince and Wooster's measurements should give the 'static' values. Probably the theory of diffuse scattering of X-rays needs some modification in the light of the new theory of elasticity.

The new theory demands the two invariants (1) and (3), the former only being pointed out by Viswanathan[10]. Using the following relations, the values of the four elastic constants $d_{11}$, $d_{12}$, $d_{44}$, $d_{45}$ have been calculated.

$$d_{11} = C'_{11} = C_{11}\,;\quad d_{44} = C'_{44}\,;$$

$$d_{45} = (2C_{44} - C'_{44})\,;\quad d_{12} = (C'_{12} + 2C'_{44} - 2C_{44})$$

The average values of $C_{ij}$ and $C'_{ij}$ have been used to calculate the $d_{ij}$'s and the numerical values obtained are :

$$d_{11} = 101{\cdot}9\,;\ d_{12} = 36{\cdot}6\,;\ d_{44} = 54{\cdot}9\,;\ d_{45} = 32{\cdot}1 \times 10^{11}$$

Table 2*

| Authors | Method of measurement | $C_{11}$ | $C_{12}$ | $C_{44}$ | $(C_{12} + 2C_{44})$ | $(C_{11} + 2C_{12})/3$ |
|---|---|---|---|---|---|---|
| Bhagavantam and Bhimasenachar | Wedge method | 95 | 39 | 43 | 125 | 57·7 |
| Prince and Wooster | X-ray diffuse scattering | 110 | 33 | 44 | 121 | 58·7 |
| Mean | — | 102·5 | 36·0 | 43·5 | 123·0 | 58·2 |
| | | $C'_{11}$ | $C'_{12}$ | $C'_{44}$ | $(C'_{12} + 2C'_{44})$ | $(C'_{11} + 2C'_{12})/3$ |
| McSkimin and Bond | Pulse phase comparison | 107·6 | 12·5 | 57·6 | 127·7 | 44·2 |
| Present authors | Thermal scattering | 94·9 | 15·1 | 52·1 | 119·3 | 41·7 |
| Mean | — | 101·3 | 13·8 | 54·9 | 123·5 | 43·0 |
| Williamson | Static | — | — | — | — | 56·0 |
| Theoretical | — | *101·9* | 39·9<br>14·3 | 41·8<br>54·5 | *123·3* | |

* Values in italics were used in calculating the two unknown force constants.

Using these values three further relations have been verified:

(1) $d_{12}(36{\cdot}6) = C_{12}(36{\cdot}0)$
(2) $(d_{11} + 2d_{12})/3\,(58{\cdot}4) = \varkappa(56)$
(3) $d_{12} + d_{44} + d_{45}\,(123{\cdot}6) = C_{12} + 2C_{44}(123{\cdot}0)$
$= C'_{12} + 2C'_{44}\,(123{\cdot}3)$

The existence of the four elastic constants in diamond has thus been definitely established.

We note that in diamond, $d_{12}$ is nearly equal to, but distinctly different from, $d_{45}$. This is what is to be expected from the (42) equations given by Viswanathan[10]. This difference between $d_{12}$ and $d_{45}$ is due to the lattice-displacement term, which is small even in diamond. In the case of other cubic crystals having all the atoms at the centres of symmetry, such as sodium chloride, this lattice-displacement term is zero and hence $d_{12} = d_{45}$; but $d_{44}$, in general, will not be equal to $d_{45}$. In diamond, the difference between $d_{44}$ and $d_{45}$ is large, as is to be expected from the pronounced covalent bonding.

The values of the four elastic constants can be calculated from the atomic force constants. The elastic constants have been evaluated otherwise by Viswanathan[10], but the two sets $C'_{ij}$ and $C_{ij}$ have not been clearly analysed. Taking the average values of $C_{11} = C'_{11}$ $(=101{\cdot}9)$ and $C_{12} + 2C_{44} = C'_{12} + 2C'_{44}$ $(=123{\cdot}3)$ and combining these with Ramanathan's[11] evaluation of the force constants from the spectroscopic behaviour of diamond to calculate the two unknown force constants, we get:

$$d_{12} = 39{\cdot}9\,;\ d_{44} = 54{\cdot}5\,;\ d_{45} = 28{\cdot}9 \times 10^{11}$$

The values for $C_{12}$, $C_{44}$, $C'_{12}$ and $C'_{44}$, calculated on this basis, are given in the last row of Table 2. The agreement with the observed values is quite satisfactory, and affords further confirmation of our identification.

Accurate measurements of Young's modulus for diamond along the [100] and [111] directions would afford an additional test of the validity of the new theory of elasticity.

Work on other aspects of this problem is continuing and will be published in due course.

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## Fluorescence of Adsorbed Water

In previous communications[1] I have discussed what I called 'the reversibility of fluorescence by annealing' which I attributed in the case of chemicals and some pulverized minerals (anhydrite, desmine, colemanite) to adsorbed water, and in the case of the feldspars, which I studied in the form of larger pieces, to contamination by contact with the skin of the hand.

I have now observed the reversible fluorescence due to adsorbed water in feldspars which are sufficiently finely powdered, when the fluorescence destroyed by heating can also be regenerated by wetting or by long exposure to the air. Thus the greenish-blue fluorescence of these minerals can be attributed to adsorbed water which, in their natural state, is probably of magmatic origin. This explains the paradox that feldspars formed from the magma show a fluorescence that can be destroyed by heating; there is no evidence for radio-photofluorescence in feldspars which might otherwise have explained this phenomenon.

The fluorescence of adsorbed water, first discovered by Ewles[2], is fairly widely distributed in the mineral kingdom. It is characterized by a broad band in the blue with one or two peaks between 430 and 480 mμ; it can be destroyed by strong annealing and regenerated by weaker heating after a short exposure to damp air, and by longer exposure to the atmosphere at room temperature, as well as by wetting. In many cases the fluorescence in the natural state is also increased by weak annealing.

The bluish colour of the fluorescence is often changed to orange-yellow by annealing, due to the relative enhancement of a long-wave band; it is not clear whether this is due to another activator or to the formation of certain lattice defects. This effect has already been observed in the case of calcite by Kreutz[3] and Déribéré[4], who also noticed the part played by water.

The reversibility of fluorescence by annealing has recently been found in alumina and silica under conditions which exclude any contamination; the only substances with which the powders were in contact, apart from the air of the room, being the interior of Jena glass tubes and platinum cleansed by heating to yellow heat.

Wawilow and Tummermann[5] have observed a bluish fluorescence of water that can be removed only with difficulty by repeated distilling. I have now found that freshly fallen snow and its melt-water, excited by ultra-violet light, display a bluish fluorescence with a peak at 430 mμ, in sufficient agreement with the results of Wawilow and Tummermann. Those authors tentatively ascribe the fluorescence to oxygen, whereas Ivekovic[6] attributes it to organic impurities. It seems possible, however, that this fluorescence, too, may be due to the adsorption of water, not on a solid body but on the molecules of some impurity.

As to the fluorescence of skin[1,7], which first led to a mistake in the case of the feldspars, the following observations may be added. The aqueous extract of heated skin is brightly fluorescent; on evaporation a brown deposit is formed which is only faintly fluorescent. Rewetting, however, immediately restores the fluorescence.

I wish to thank Dr. H. Adler for his help in these investigations.

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## Energy Spectrum of Particles Bombarding the Earth

INTERSTELLAR matter may be captured by the gravitational field of the Sun. Harrower[1] suggests that this matter is intercepted by the Earth's atmosphere at the 400-km. level, giving rise to radio-star scintillation. He estimates[1] the flux of hydrogen atoms or nuclei of about 10 eV. as of order $10^{13}$ cm.$^{-2}$ sec.$^{-1}$.

Balmer emissions with Doppler shifts corresponding to proton velocities of order 1,000 km./sec. (energy $10^4$ eV.) have been observed in auroral displays. The flux of protons has been estimated[2] as of order $10^7$–$10^8$ cm.$^{-2}$ sec.$^{-1}$. Protons coming from outside the Earth's atmosphere and penetrating to auroral depths must have incident energies of order $10^5$ eV. Very little is known about when and where auroral protons reach the Earth.

In the energy region above $10^9$ eV., cosmic rays follow an integral energy ($E$) spectrum given[3] by $N\ (>E) \propto E^{-1.5}$. The exponent may increase for $E > 10^{16}$ eV.

The cosmic-ray integral energy spectrum is plotted as a solid line in Fig. 1. The estimated fluxes of interstellar and auroral particles appear to fit the straight-line portion of this spectrum extrapolated to lower energies.

This fit could not be predicted *a priori*, and according to present theories it must be fortuitous or based on inaccurate estimates. Clearly, it is important to examine the intermediate energy intervals.

As shown in Fig. 1, the cosmic-ray spectrum appears to be cut-off at an energy of about $10^8$ eV. However, it is known that the flux of particles in this energy region varies greatly with solar activity[4]. It may be supposed, then, that this cut-off is due to some solar influence[5].

The geomagnetic field and the shielding nature of the atmosphere also influence measurements in the energy-range about $10^5$–$10^8$ eV. However, Winckler *et al.*[5] have found a possible association between cosmic radiation and auroral activity. Also Van Allen and others[6] measured the flux of soft radiation at rocket altitudes as much greater at the northern auroral zone than elsewhere.

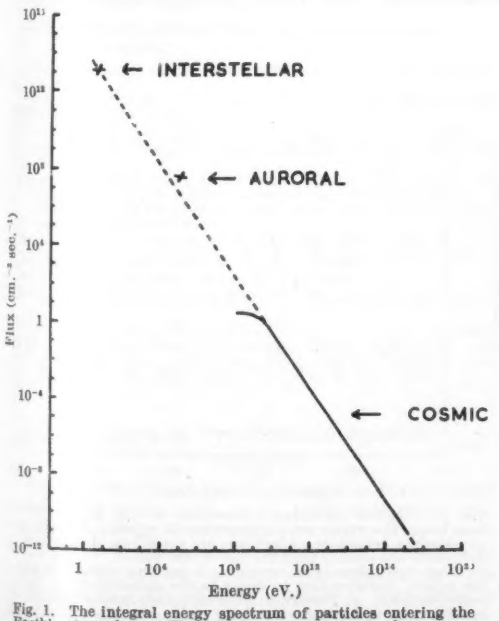


Fig. 1. The integral energy spectrum of particles entering the Earth's atmosphere. The cosmic-ray spectrum is shown as a solid line

Recent measurements using artificial Earth satellites have indicated that the flux of ionizing radiation at an altitude of 1,000 km. is about one thousand times the flux at 100 km. This might be interpreted as further evidence for a continuation of the energy spectrum between $10^6$ and $10^8$ eV.

The energy-range around $10^6$ eV. could be studied by examining height – intensity distributions of auroral Balmer emissions. No accurate measurements are available, and the point plotted in Fig. 1 represents the integral flux estimated by several workers[2]. Chamberlain has found[2] that an integral energy spectrum of $E^{-1/2}$ may govern the auroral protons. However, the uncertainties in this estimate are considerable.

To my knowledge, no quantitative measurements in the energy-range between 10 and $10^5$ eV. have been reported.

Since first considering the data presented in Fig. 1, I have seen a recent paper by Parker[7]. He has shown that the cosmic-ray gas can be effectively coupled to motions of ordinary matter, and that this represents a state of general dynamic balance. This treatment suggests that the relation noted in Fig. 1 may not be fortuitous. Clearly, much more theoretical and experimental study of the problem is essential.

Stimulating discussions with members of the Antarctic Division are gratefully acknowledged.

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## Coherent Scattering of 1·33 MeV. γ-Rays by Lead

THE cross-section for coherent (elastic) scattering of γ-rays from a heavy atom is expected to include a contribution from Delbrück scattering, the scattering of light by a static electric field[1]. This contribution should appear as a deviation of the experimental cross-section from the cross-section calculated taking only Rayleigh scattering and nuclear Thomson scattering into account; but uncertainties in both theory and experiment have made it difficult to draw any definite conclusions from the results at low energies[2,3].

We have measured the differential cross-section for elastic scattering of 1·33 MeV. γ-rays from lead using a larger γ-ray source than previous workers[2], and using a different method[4] of examining the scattered γ-ray spectrum. In this method a scintillating crystal is viewed by two photomultipliers 1 and 2, the spectrum of 'gated' pulses from 1 being recorded: thus a pulse from 1 is recorded if it coin-

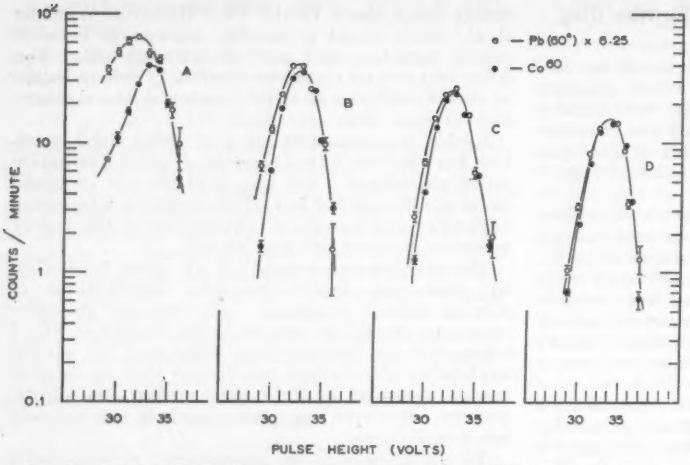


Fig. 1. Gated pulse-height spectra recorded in photomultiplier-1 for various gate voltage settings in photomultiplier-2—the gate voltage increases going from *A* to *D*. ○, γ-Rays scattered from lead at 60°; ●, γ-rays from the small cobalt-60 source *b* at the target position. The counting-rate from the scattered γ-rays has been multiplied by 6·25 in each case

cides with a pulse from 2 greater than a 'gate voltage' *V*. By increasing *V*, the proportion of inelastic scattering included in the measured elastic scattering cross-section may be made negligible.

γ-Rays from a cobalt-60 source *a* (about 1,500 curies) impinged on a lead target (15 cm. × 15 cm.) and the scattered radiation was observed by a NaI(*T*1) crystal (about 20 cm.³) shielded from background by about 1,200 lb. of lead. The distances source–target and target–crystal were both about 100 cm., so that the angular resolution was between 1 and 2 deg. Measurements under identical conditions were alternated between the scattered radiation ($n_a$ counts/min.) and the direct radiation from a small cobalt-60 source *b* placed at the target position ($n_b$ counts/min.). In each case, light pulses from the crystal were viewed by two photomultipliers[4] as described above. Fig. 1 shows the recorded pulse-height spectra. If no inelastic scattering is being recorded the scattered γ-ray spectrum should have the same shape as the spectrum of the cobalt-60 source. It is clear from Fig. 1 that for low gate voltage considerable inelastic scattering was included—from experiments with thin targets we have found this to be mainly a primary effect (and not a secondary effect of photoelectrons produced by the γ-rays in the target) and to be qualitatively consistent with the Compton scattering expected from bound electrons[5]. As the gate voltage was raised (Fig. 1) the scattered γ-ray spectrum approached that of the cobalt-60 source, giving the ratio $n_a/n_b$ directly. Corrections were made for background ($\lesssim$ 30 per cent) and for target absorption ($\lesssim$ 15 per cent).

At every angle sufficient lead absorber (1–3 in.) was put between the target and the counter to make pile-up negligible. To guard against systematic errors caused by a shift of photomultiplier gain with counting-rate[6], the small cobalt-60 source was accompanied by a cæsium-137 source large enough to give a total photomultiplier current equal to that when the scattered radiation was observed. In addition, we selected as one of our photomultipliers a tube having a gain which increased with increasing counting-rate, and as the other a tube having the opposite characteristics—the change of gain with counting-rate was of the same order of magnitude in the two cases. Measurements taken when first one and then the other of these photomultipliers acted as gating tube, gave upper and lower limits on the ratio $n_a/n_b$. In all cases, except for the smallest two angles, these agreed within the standard deviations, and for the smallest angles we believe that the combined results are within the standard deviations.

The absolute scattering cross-section is determined by the ratio $n_a/n_b$, the number of target atoms, the source–target distance, and the ratio $a/b$ of source strengths. The ratio $a/b$ was measured in two steps, using an intermediate source *d* of about 150 mc. First the ratio $d/b$ was measured directly by counting the γ-rays from the sources under identical conditions. Then absorption curves for *a* and *d* (overlapping for a half-thickness) were taken with the same geometry for each. Both curves were exponential and gave an absorption coefficient agreeing with Colgate's value[7], so their ratio was taken for $a/d$.

Our experimental cross-sections are shown in Fig. 2. They are lower than those of Bernstein and Mann[2] by factors of 1·3–2·5, and also are much lower than the earlier experimental results[3], but are in fair agreement with the measurements of Goldzahl and Eberhard[3] within the errors of the latter (± 20 per cent).

Fig. 2 also shows the theoretical coherent scattering cross-section. The *K*-shell Rayleigh scattering was

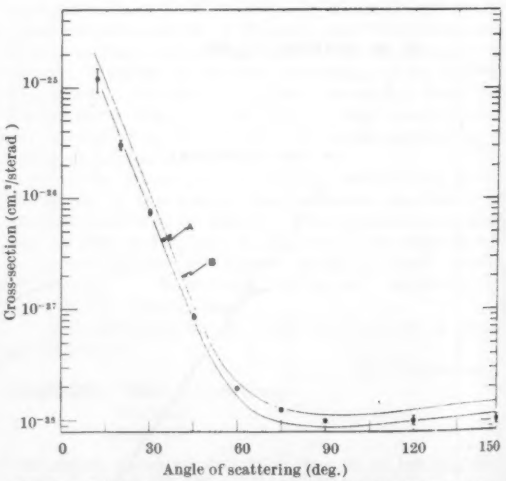


Fig. 2. Coherent scattering cross-section of 1·33 MeV. γ-rays from lead. The points are our experimental points and the bars are standard deviations—where bars are not shown the standard deviations are smaller than the size of the points. In addition to these errors there is an error of ± 5 per cent common to all the points, corresponding to errors in the measurement of the source ratio $a/b$. *A*, Theoretical cross-section for nuclear Thomson scattering and Rayleigh scattering from the *K*-shell only; *B*, theoretical cross-section for nuclear Thomson scattering and Rayleigh scattering from the *K*- and *L*-shells

calculated from Brown and Mayers's exact calculations for mercury[3]. These were corrected to lead by multiplying the amplitude for polarization change by the ratio of form factors at each angle, and by multiplying the amplitude for no polarization change by the ratio of Brown and Mayers's 'corrected form factors' at each angle, giving corrections less than, or approximately equal to, 15 per cent in cross-section. The *L*-shell scattering was calculated from the form factor for polarization change and from the 'corrected form factor' for no polarization change.

It is clear from Fig. 2 that if the theoretical results for *K*- and *L*-shells are taken literally, we find an appreciable difference between theory and experiment, amounting, for example, to about 30 per cent at 30°. This difference appears to be qualitatively consistent with present theoretical knowledge of Delbrück scattering[8]. Unfortunately, however, the only accurately calculated Rayleigh cross-section is for scattering from the *K*-shell in mercury[3], and the corrections from mercury to lead and for the contribution of the *L*-shell are of the same order of magnitude as our difference. Furthermore, it appears likely, from the results for the *K*-shell[3], that our *L*-shell calculation is a considerable over-estimate. Therefore, we believe that a final answer as to the presence of Delbrück scattering in our experimental results must await more accurate calculations.

A more detailed report on this work will be published in the *Canadian Journal of Physics*. We are particularly indebted to the Manitoba Cancer Foundation for permission to use its cobalt-60 beam-therapy unit and to the National Research Council of Canada for financial support. We also thank Dr. A. Bernstein, Dr. G. E. Brown and Dr. A. K. Mann for informative discussions and for communication of their results before publication, and Mrs. P. Barnes and Mr. G. Hardie for valuable assistance.

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## Structure of Precipitated Apatitic Phosphates

Tricalcium phosphate (calcium/phosphorus weight ratio, 1·94) is thought to be hydroxylapatite (calcium/phosphorus, 2·15) with phosphate ions chemisorbed. When immersed in lime solutions, this tricalcium phosphate becomes more alkaline and the ratio rises to 2·15. Kinetic studies of lime fixation show that the reaction is not instantaneous. Therefore, it is questionable whether phosphate ions previously in excess should be located on the surface only. On the other hand, the existence of cation defects in the crystalline lattice itself is unlikely.

We think that precipitates of synthetic phosphates must be especially tiny microcrystals, more or less agglomerated, in bigger particles. In such agglomerates, properties connected with structure are not necessarily the same as in perfect macrocrystals. This would account for some properties of the iso-ionic exchange, as well as for other properties of synthetic precipitated phosphates[1].

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## Catalytic Activity and Surface Structure after Ion Bombardment

Single crystals of silver have been prepared with surfaces having an orientation within 2° of the (111) plane. After bombardment with low-energy argon ions the surfaces have been studied by: (1) measurements of the rate of the catalytic decomposition of formic acid (zero-order reaction); (2) electron diffraction in transmission and reflexion. The results of these experiments suggest that the catalytic decomposition of formic acid on silver occurs at points on the surface where dislocation lines emerge.

*Catalysis.* The reaction-rate was always expressible as a function of the absolute temperature, $T$, in the form $A \exp(-E/RT)$. When this was done, both $A$ and $E$ changed with the energy of the bombarding ions. For example, for a maximum ion energy of 14 eV. the value of $E$ was 12·2 kcal./mole; for a maximum ion energy of 77 eV. $E$ became 20·8 kcal./mole and the value of $A$ increased by a factor of $10^{5\cdot2}$. In these experiments the same crystal was used as the catalyst after bombardment with ions of various energies, and the changes in $E$ and $A$ have clearly to be ascribed to a change in the surface due to the bombardment.

We have been able to account for the changes in $A$ only by supposing that there is an increase in the number per unit area of 'active places' on the surface where the reaction can occur. The important feature of these specific sites may be geometric or electronic or both. Assuming that for a given treatment there is mainly one type of site, so that $A$ gives a simple measure of the number of sites, we can say that this number has been increased by the bombardment by a factor of at least $10^{5\cdot2}$. This large increase must be associated with a change in the number of surface defects caused by ion bombardment. Since the crystal is annealed at 250° C. before the measurements are made—and at this temperature defects other than dislocations are reduced to low numbers—this change is most likely to be the result of a change in the number of dislocation lines intersecting the surface.

*Electron diffraction.* Evidence supporting this last conclusion was obtained from the electron diffraction studies. Bombardment at 14 eV. produced no detectable structure changes in the surface, although silver was removed. Bombardment at 77 eV., however, resulted in the surface layer down to about 100 A. becoming disoriented, small crystalline blocks being rotated with respect to one another mostly through angles of a few degrees. The low angle boundaries between these blocks are commonly described in

terms of arrays of dislocations, and the disorientation was found to be comparable to that produced in a crystal of a very heavily cold-worked polycrystalline aggregate in which it is well known that the number of dislocations is about $10^5$ times that in an annealed crystal. This implies that the increase in the number of dislocation lines cutting the surface after bombardment at 77 eV. is of the order of $10^5$ times the number after bombardment at 14 eV. This increase is similar to that in the number of sites found from the catalytic experiments. We therefore consider that the electron diffraction evidence gives strong support to the conclusion that dislocations cutting the surface provide sites for the reaction.

This work will be fully reported elsewhere.

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June 30.

## Tritium and Paper Chromatography

Since hydrogen is an element of fundamental interest in life processes, it is important to have a method for studying its pathway through living systems. If, in paper chromatography, one is using a radioactive tracer, a sheet of X-ray film can be placed on top of the chromatogram and the labelled compounds then produce darkened spots on the film[1]. Unfortunately, in the case of hydrogen, only tritium is radioactive, and this decays by the emission of a very soft β-particle (18 keV.), the range of which is so low that it is absorbed before it can leave the paper and enter the film. This communication describes a technique of 'scintillation autography' whereby this difficulty is overcome. The technique involves soaking the chromatogram in a liquid scintillator so that the energy of the disintegrating tritium atoms is converted into light which is detected by a film. Thus a weak β-particle is converted into light quanta which can travel into the film to produce an image. By the use of fast film, small amounts of compounds labelled with tritium can be separated and identified in only a few days.

This technique is used in our laboratories for researches on the path of hydrogen in photosynthesis. A typical experiment is described to illustrate the technique.

25 mgm. of washed algae (*Chlorella*) are centrifuged to the bottom of a conical centrifuge tube. As much water as possible is removed, since it will lower the specific activity of the tritiated water. 50 mc. tritiated water (4 c./ml.) are added under the particular conditions of the experiment and the whole rapidly agitated with a stream of air with 4 per cent carbon dioxide. At the end of the experiment absolute methanol is added to kill the algae. After extraction with alcohol and water, the extracts are evaporated under vacuum and placed on one corner of a piece of Whatman No. 4 filter paper (15 cm. × 15 cm.) washed in oxalic acid. After development the chromatogram is attached to some suitable backing material with wire staples (used X-ray film is suitable). A spot of extract from algae or yeast labelled with tritium is placed on a piece of filter paper and when dry cut into segments. These segments are then attached to the corners of the backing sheet with staples. These later provide reference points on the backing sheet and also on the film with which to line up the film and the original chromatogram, thus identifying a spot with a definite area on the paper chromatogram. The backing sheet thus prepared is laid in the bottom of a shallow tank and covered with a scintillating liquid (for example, 3 gm./l. *p*-diphenyl benzene in sulphur-free toluene). A sheet of film is next placed on top of the chromatogram, taking care to eliminate any bubbles. The tank is then covered with an air- and light-tight top. After a few days, the film is removed from the tank, drained of scintillating liquid and allowed to dry. It is then developed and fixed in the normal manner. Such a 'scintillation autogram' is shown in Fig. 1. Thus, as in carbon-14 radioautography, compounds can be tentatively identified by their position and this identification confirmed by removal from the paper and co-chromatography with known compounds, or by chemical treatment and re-chromatography.

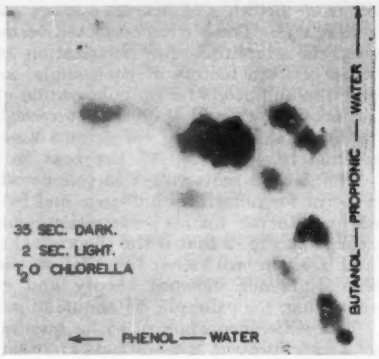


Fig. 1. Example of scintillation autograph

As can be seen, the quality and sharpness compares favourably with radio-autograms produced by beta-particles from carbon-14. Although this technique has been used to study the 'photo' part of photosynthesis in our laboratories, it could also be applied to many other biological and chemical problems. In view of the cheapness and availability of tritium ($10^{-4}$ that of carbon-14), and also the ease of its introduction into complicated organic molecules (by exposure to tritium gas[2]), it should be possible to use it to discover the biological fate of some of the more complex organic materials which are difficult to synthesize with carbon-14. This new technique also provides a method of preparing chromatographically pure tritium-labelled compounds. This overcomes the principal difficulty in the Wilzbach synthesis[3], which yields a product contaminated with small amounts of tritium-labelled material of high specific activity, the removal of which by other means is both tedious and difficult.

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## A New Method for preparing Scaly Alumina

SCALY alumina is a hydrous alumina with white iridescent scales, similar to white mica sheets. It was first prepared by Neogi and Mitra as the product of the reaction of aluminium amalgam with aqueous barium nitrate solution[1]. The conditions for the formation of scaly alumina were re-investigated by Biltz and Lehrer[2], who found that a saturated barium nitrate solution, at room temperature, gives the highest yield of well-formed sheets of scaly alumina. Neogi and Mitra gave the composition $Al_2O_3.4H_2O$ for the scaly alumina, but this was not confirmed by Weiser[3]. Scaly alumina was considered by Weiser to be a form of Wislicenus's fibrous alumina, but this is not true, since fibrous alumina is formed in conditions different from those in Neogi and Mitra's or Biltz and Lehrer's methods[4].

During studies on the fine structure of scaly alumina by electron microscopy, X-ray diffraction and differential thermal analysis[5], a new method was developed for preparing scaly alumina using hydrogen peroxide instead of the barium nitrate solution. This new method yields a substance identical in appearance to the scaly alumina prepared by the other methods, with the advantage that it is free from the barium and ammonium compounds which are formed in the reduction of the barium nitrate by the aluminium amalgam.

The procedure for preparing the scaly alumina is as follows: a 6 cm. × 6 cm. piece of 99·95 per cent pure aluminium sheet, 0·5 mm. thick and weighing about 5 gm., is washed in a 1-litre beaker, first with acetone, then with *N* sodium hydroxide solution and finally with distilled water to remove the sodium hydroxide; 100 ml. of a saturated mercuric chloride solution are added to the beaker and left to react with the aluminium until the latter is covered with an adherent layer of liquid mercury; the greyish turbid liquid is rejected and the amalgamated aluminium sheet is washed five times with 500 ml. of distilled water to remove the mercury salts; 1 kgm. of twice distilled mercury is added to the beaker, and immediately followed by the addition of cold 3 per cent hydrogen peroxide solution. The amalgamated aluminium sheet floats on the surface of the mercury, covering it almost completely and starts reacting with the hydrogen peroxide solution, with a strong production of gas and heat. The beaker is placed in a refrigerator at 4–5° C. to slow down the reaction; after 24 hr. the surface of the mercury is covered with a thick layer of white iridescent sheets of scaly alumina.

The scaly alumina may be separated from the hydrogen peroxide solution and from the mercury by filtration in a Buchner funnel without filter paper, and washed with distilled water. It must be dried at room temperature, in air or in a vacuum desiccator to preserve its iridescent scaly appearance, which is lost when it is dried at more than 70° C. The amount of scaly alumina obtained by this procedure corresponds to a yield of 40–45 per cent from the original weight of the aluminium sheet. The amalgamated aluminium sheet, floating on the surface of the mercury, gives better sheets of scaly alumina than does the aluminium amalgam, prepared from aluminium powder[6], in Biltz and Lehrer's method[2]. If the reaction is allowed to proceed until all the hydrogen peroxide in the solution is used up or if the temperature becomes too high, no scaly alumina is formed, but a dark grey powder appears, as in the reaction of strongly amalgamated aluminium with water[7].

Table 1

| Substance | Loss on ignition (per cent) |
|---|---|
| Scaly alumina, Biltz and Lehrer's method (ref. 2) | 31·4 |
| Scaly alumina, $H_2O_2$ method | 38·3 |
| $Al_2O_3.3H_2O$ (theoretical) | 34·7 |
| $Al_2O_3.4H_2O$ (theoretical) | 41·4 |

Table 1 shows the results of the determinations of the loss of weight on ignition at 1,200° C. of samples of scaly alumina prepared by Biltz and Lehrer's methods and by the procedure described above. These results are for samples dried at 110° C. to constant weight. For comparative purposes, the theoretical ignition losses of an alumina trihydrate and a tetrahydrate are also presented in the table.

These results show that the scaly alumina prepared by Biltz and Lehrer's method is closer in composition to an alumina trihydrate than to a tetrahydrate. The lower ignition loss is probably due to barium impurities adsorbed between the layers of the scaly alumina. The scaly alumina prepared by my method is closer in composition to an alumina tetrahydrate; however, no alumina tetrahydrate exists[8], only the mono- and tri-hydrates. Therefore, the scaly alumina prepared using hydrogen peroxide solution must be an alumina trihydrate with some water adsorbed between the layers. These results are confirmed by the X-ray powder diffraction data of the samples prepared by both methods[5]. A detailed study on the structure of the scaly alumina will be published elsewhere.

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## α-(*p*-Nitrophenyl)Maltoside as a Substrate for the Assay of Amylase

RECENT methods for the assay of amylase use polysaccharides, mostly starch solutions, as a substrate. The wide range of the results can be ascribed in part to the properties of polysaccharides in solution. In starches the ratio of amylose to amylopectin is variable and, according to Meyer, long-chain polysaccharides in solution tend to form particles resistant to enzyme. The affinity of amylase for the substrate diminishes with decreasing chain-length. The maltose set free acts as an inhibitor of amylase (cf. Meyer *et al.*). Moreover, the moderate accuracy of the usual (iodometric and reductometric) methods of measuring chain-length may affect the results unfavourably.

An improved method for the assay of amylase seemed possible, using maltotriose as a substrate.

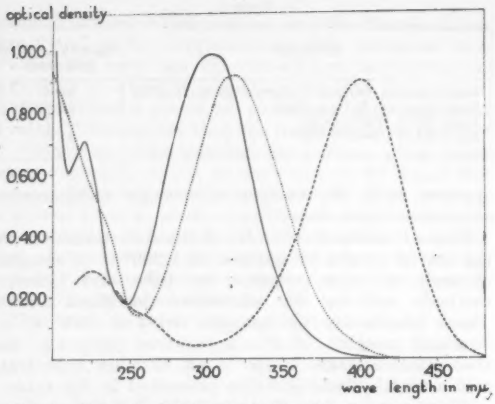


Fig. 1. Absorption spectra of α-(*p*-nitrophenyl)maltoside in acid and alkaline solution (solid line) and of *p*-nitrophenol in acid (dotted line) and alkaline solution (interrupted line). 'Unicam' spectrophotometer 500, 10-mm. cuvettes, intervals of 5 mμ

However, unanimity does not exist about the action of amylases on maltotriose. According to Meyer *et al.*[1] and Pazur *et al.*[2], maltotriose is broken down to glucose and maltose at a very slow rate, whereas Wheelan *et al.*[4] and Myrbäck *et al.*[5] deny that maltotriose is degraded by salivary amylase.

We have studied the breakdown of maltotriose photometrically, using α-(*p*-nitrophenyl)maltoside as a substrate. The strong yellow colour of *p*-nitrophenol, set free during hydrolysis, makes it possible to measure a slight degradation and to avoid high concentrations of maltose.

Synthesis of α-(*p*-nitrophenyl)maltoside was performed by the following procedure, analogous to the synthesis of 4-methyl-α-(*p*-nitrophenyl)glucoside by Berger[6]:

Maltose + acetic anhydride → octa-acetylmaltose

Octa-acetylmaltose + *p*-nitrophenol $\xrightarrow{TiCl_4}$ (*p*-nitrophenyl)hepta-acetylmaltoside

(*p*-Nitrophenyl)hepta-acetylmaltoside $\xrightarrow{\text{sodium methylate}}$ methylacetate + *p*-nitrophenyl maltoside

(*p*-Nitrophenyl)hepta-acetylmaltoside + methanol → methylacetate + *p*-nitrophenyl maltoside

Titanic chloride catalyses formation of the α-form of glycosidic linkage[6]. Absorption spectra of the amorphous substance in alkaline and acid solution were identical, indicating linkage of the phenolic OH-group of *p*-nitrophenol to maltose (Fig. 1). *p*-Nitrophenol was set free while boiling with alkali.

Hydrolysis of the substrate was obtained during incubation with saliva, urine, duodenal contents and incidentally with serum.

Table 1. Influence of High Temperature (boiling 15 min.) and Protein Precipitants on Hydrolysis of α-(*p*-nitrophenyl)maltoside by Human Urine and Saliva, expressed as Optical Density at $\lambda = 410$ mμ

| | Untreated | Boiled | 10 per cent trichloracetic acid | | 0·5 *N* silver nitrate |
|---|---|---|---|---|---|
| | | | 0·1 ml. | 0·2 ml. | 0·1 ml. |
| Urine | 0·190 | 0·020 | 0·090 | 0 | 0 |
| Saliva | 0·320 | 0 | 0·130 | — | 0 |

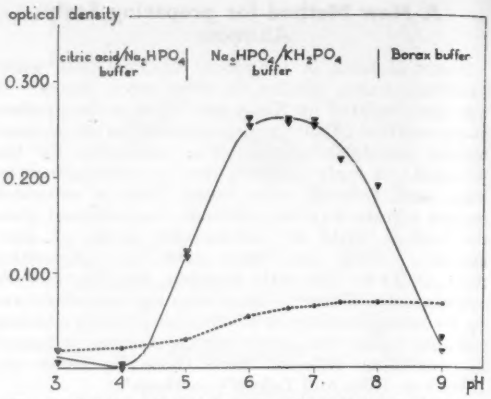


Fig. 2. Relationship between *p*H and hydrolysis of α-(*p*-nitrophenyl)maltoside by human urine, expressed as optical density at $\lambda = 410$ mμ. The dotted line represents the hydrolysis of the blanks, measured against water

2 mgm. of substrate, dissolved in 3 ml. of 1/15 *M* phosphate buffer (*p*H 6·5) were incubated with 0·1 ml. of the material to be tested at 37° C. for 16 hr. Then 10 ml. of 0·02 *N* sodium hydroxide were added. Production of *p*-nitrophenol was measured photometrically at 410 mμ. For each determination a blank was prepared by adding the material to be tested to the incubated substrate after it had been made alkaline. If necessary, enzyme solutions were diluted so as to produce optical densities less than unity.

The rate of hydrolysis is dependent on the *p*H (Fig. 2) with an optimum at *p*H 5·9–7·0. High temperature and protein precipitants inhibit hydrolysis (Table 1). These results suggest an enzymatic activity. The relationship of hydrolysis to enzyme concentration is linear; *p*-nitrophenol does not inhibit the reaction.

Apart from the possible existence of an unidentified carbohydrase[4,7], our results suggest that human amylase is able to degrade maltotriose to glucose and maltose, so that α-(*p*-nitrophenyl)maltoside may be a suitable substrate for the assay of amylase.

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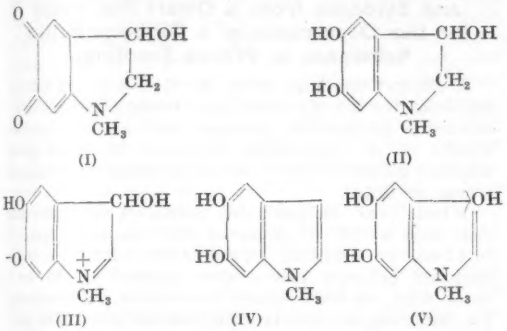
## Reduction of Adrenochrome with Ascorbic Acid

The discharge of the intense red colour of aqueous solutions of adrenochrome (I) by various reducing agents has been reported by several workers[1,2]. The reaction apparently does not simply consist of the reduction of the orthoquinone moiety of the molecule with the production of the hypothetical 'leucoadrenochrome' (2 : 3-dihydro-3 : 5 : 6-trihydroxy-N-methylindole) (II). Harley-Mason, in describing the reduction with sodium hydrosulphite or hydrogen

(catalytic), postulated the initial addition of one atom of hydrogen to the molecule, with the formation of an unstable intermediate which disproportionates into (II) and a zwitterionic compound (III). The former (II) appears to be inherently unstable and readily loses water, with the formation of 5 : 6-dihydroxy-N-methylindole (IV); the second substance (III) isomerizes under the influence of alkali to adrenolutin (3 : 5 : 6-trihydroxy-N-methylindole) (V)[2,3].




The reduction of adrenochrome with ascorbic acid, a reaction which may have physiological significance, has been reported by Beauvillain and Sarradin[4] and by Fischer[5], who reported that this reduction product is not the same as that produced by sodium bisulphite. However, the isolation of definite reduction products was not described in either case.

We have studied the ascorbic acid – reduction products of adrenochrome, both in aqueous and methanolic solution, by paper chromatography, and the results indicate the presence of three or possibly four compounds giving chromogenic reactions characteristic of indole derivatives. All these substances also exhibited fairly marked reducing properties. The excess ascorbic acid and resulting dehydroascorbic acid were also easily detected.

Spots consisting of 10–60 μlitres of the reaction mixture (prepared from adrenochrome (0·05 gm.) and ascorbic acid (0·25 gm.) in 10 ml. solvent) were examined on Whatman No. 1 paper (previously washed with 2 per cent acetic acid) in three solvent systems: (*A*) 2 per cent acetic acid in water; (*B*) *n*-butanol/acetic acid/water (6 : 1 : 2) and (*C*) acetonitrile/acetone/water/acetic acid (80 : 5 : 15 : 1).

The chromogenic reagents employed were: (1) Ehrlich's reagent; (2) cinnamaldehyde; (3) Hopkins-Cole reagent[6]; (4) Salkowski reagent; (5) Gibbs phenol reagent; (6) diazotized *p*-nitroaniline; (7) ammoniacal silver nitrate; (8) ferric chloride-potassium ferricyanide[7]; (9) dichlorophenol-indophenol and (10) 2 : 4-dinitrophenylhydrazine.

The results obtained are given in Table 1.

In *A*, the $R_F$ zone 0·42 ± 0·01 exhibited the characteristic colour reactions of indoles and *o*-catechols and was due to (IV). (An authentic sample of (IV) prepared from (V)[3] had the same $R_F$.) The zone $R_F$ 0·83 ± 0·03 was due to dehydroascorbic acid and unchanged ascorbic acid. (Authentic specimens of these acids had $R_F$'s of 0·86 and 0·85 respectively in this solvent; ascorbic acid gave a black spot, whereas dehydroascorbic acid gave a golden-brown spot with ammoniacal silver nitrate.) The unknown substances (VI) and (VII) with $R_F$ values of 0·56 ± 0·02 and 0·65 ± 0·05 respectively showed modified indole reactions together with phenolic and reducing properties. In *B* (IV) had an $R_F$ of 0·76 ± 0·02, (VI) had an $R_F$ of 0·27 ± 0·01 and once again ascorbic acid and dehydroascorbic acid were not efficiently separated and were present in the zone $R_F$ 0·39 ± 0·02. (Authentic samples had $R_F$'s of 0·36 and 0·42 respectively.) In *C* (IV) had an $R_F$ of 0·96, (VI) had an $R_F$ of 0·55 ± 0·02 and the two acids were observed at an $R_F$ of 0·37 ± 0·02.

Table 1. $R_F$ VALUES OF MAJOR REACTION PRODUCTS IN VARIOUS SOLVENT SYSTEMS (see text)

| *A** | *B* | *C* |
|---|---|---|
| 0·42 ± 0·01 | 0·27 ± 0·01 | 0·37 ± 0·02 |
| 0·56 ± 0·02 | 0·39 ± 0·02 | 0·55 ± 0·02 |
| 0·65 ± 0·05 | 0·76 ± 0·02 | 0·96 |
| 0·83 ± 0·03 | | |

* In some cases, a weak spot was observed at $R_F$ = 0·04.

In order to obtain more information about the nature of the compounds present in the reaction mixture, the individual $R_F$ zones were eluted from the paper (larger quantities were applied in streaks to Whatman No. 3 *MM* paper and development effected with solvent *A*) and the ultra-violet spectra determined in ethanolic solution. All three zones gave similar absorption curves typical of the indole chromophore. (Zone $R_F$ 0·42 ± 0·01: $\lambda_{max.}$, 281; 301: $\lambda_{min.}$, 252; 288. Zone $R_F$ 0·56 ± 0·02: $\lambda_{max.}$, 283; 301: $\lambda_{min.}$, 255; 289. Zone $R_F$ 0·65 ± 0·05: $\lambda_{max.}$, 275; 282: $\lambda_{min.}$, 260; 279 with shoulder at about 300 mμ.) The curve obtained from the zone $R_F$ 0·42 ± 0·01 was identical with that of an authentic specimen of (IV).

Paper chromatographic examination of the products derived from adrenochrome by reduction with ascorbic acid, in aqueous solutions, after extraction with peroxide-free ether, indicated that the substance with $R_F$ 0·42 ± 0·01 was removed by the ether, while all the other products remained in the aqueous phase. Crystalline 5 : 6-dihydroxy-N-methylindole (melting point 134–135° C.; melting point of diacetyl derivative 109·5–110·5° C.) was isolated from the ethereal extract.

Other reducing agents for adrenochrome not previously reported include dihydroxymaleic acid, dihydroxyfumaric acid, cysteine, and sodium borohydride (in this case, crystalline IV has been isolated from products). These studies are being continued and further details will be published elsewhere. This investigation forms part of a programme being carried out under the auspices of the Saskatchewan Committee on Schizophrenia Research and was supported by grants from the Saskatchewan Government, the Federal Department of Health and Welfare and the Rockefeller Foundation.

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## Photosynthesis of Amino-Acids

It has been observed in this laboratory that when aqueous mixtures of dicarboxylic or monocarboxylic acids and certain ammonium salts are irradiated with ultra-violet light, certain amino-acids are obtained.

A cold quartz ultra-violet lamp giving 86 per cent of its output at about 2537 A. was used for irradiated mixtures of succinic, maleic, propionic and acetic acid with a number of ammonium salts. These mixtures were 0·1 molar both in organic acid and ammonium salt. The irradiation was continued in each case for 24 hr., the area of the irradiated solutions being 44 cm.², and the radiation intensity 7,500 microwatts/cm.² at the surface of the liquid.

Of all the ammonium compounds investigated only ammonia and ammonium carbonate were active, and of the acids only succinic, maleic and propionic acid gave rise to amino-acids.

An absorption curve in the ultra-violet region, with a peak at 2750 A., was obtained for succinic acid irradiated in presence of ammonia or ammonium carbonate. This indicates the presence of a C=O group, which was confirmed by positive tests for aliphatic aldehyde; tests for ketone were negative. Aldehydes were not detected after irradiation of maleic and propionic acids.

The irradiated solutions were evaporated to dryness, the residue taken up with acidified acetone (in 1 per cent hydrochloric acid) for desalting, the acetone was evaporated and the residue dissolved in a few drops of *iso*propylic alcohol (10 per cent in water).

Paper chromatograms were made from these *iso*propylic solutions, using phenol saturated with water as solvent for ascending chromatography in the presence of sodium cyanide and standard solutions of amino-acids for comparison.

Table 1 gives the amino-acids detected after irradiation of organic acid – ammonium salt mixtures.

Table 1. Amino-acids detected after 24 hr. Exposure to Ultra-violet, $\lambda$ = 2537 A.

| Mixture | Amounts of amino-acids found | | |
|---|---|---|---|
| | Aspartic acid | Alanine | Glycine |
| Succinic acid and ammonia | | ++ | +++ |
| Succinic acid and ammonium carbonate | | ++ | +++ |
| Succinic acid and ammonium thiocyanate | | + | |
| Maleic acid and ammonium carbonate | +++ | ++ | + |
| Propionic acid and ammonium carbonate | | | +++ |

Key: +++ very large, ++ large and + trace.

It must be concluded that ultra-violet, at a wavelength of 2537 A., is able to synthesize amino-acids from mixtures containing either a saturated dicarboxylic acid such as succinic acid, an unsaturated dicarboxylic acid such as maleic acid or a monocarboxylic acid such as propionic acid with carbonate or thiocyanate and ammonia.

The amino-acids are aspartic acid, alanine and glycine, that is to say, amino-acids with 4, 3 and 2 carbon atoms respectively.

Only succinic acid gives an aliphatic aldehyde after irradiation.

A browning reaction occurs during the evaporation of the irradiated solutions, the intensity of which is dependent on the nature of the organic acid.

A full description of the results obtained in this field will be published later.

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## A Colorimetric Test for Gibberellic Acid and Evidence from a Dwarf Pea Assay for the Occurrence of a Gibberellin-like Substance in Wheat Seedlings

A recent communication by McComb and Carr[1], reporting the use of a dwarf pea bioassay for naturally occurring gibberellins, prompts this report of some results of an experiment designed to investigate whether gibberellic acid occurs naturally in etiolated wheat seedlings.

Wheat (var. Eclipse) was grown in darkness for four days at 25° C. on moist filter paper contained in 11-cm. Petri dishes. In all, 12,500 coleoptiles with enclosed primary leaves were excised at 96 hr.; these were cut transversely into halves, representing the basal region, including the leaf meristem (135 gm. fresh weight), and the tip (205 gm. fresh weight). Basal and tip sections were frozen separately to − 15° C. in 2·5 l. of phosphate/citrate buffer of *p*H 3·8 and, after thawing, the tissue was filtered. Peroxide-free ether (3·3 l.) was passed over the tissue and shaken with the filtrate in five aliquots. The resulting ether fraction was extracted with 4·4 l. of 1 per cent sodium bicarbonate in five aliquots. This solution was then acidified to *p*H 3·0 with sulphuric acid and extracted five times with a total of 3·3 l. of peroxide-free ether.

Each of the two acidic and neutral fractions was reduced to small volume and transferred, as a series of spots on the starting line, to 25·5 cm. square Whatman No. 1 chromatography papers. Four sheets were used for each fraction. The chromatograms were developed by ascending chromatography, using the solvent system *iso*propanol/ammonia (0·880)/water (10 : 1 : 1), the papers being removed when the solvent front had moved 23 cm. Each sheet was cut horizontally into nine strips each 2·5 cm. wide; these strips were then eluted with acetone, which in each case was concentrated to 2·5 ml. The thirty-six eluates were each transferred to 25·5 cm. square Whatman No. 1 chromatography papers as a single spot for development in two directions in the solvent systems, (*a*) *iso*propanol/ammonia (0·880)/water (10 : 1 : 1); (*b*) *n*-butanol/ammonia (0·880)/water (200 : 6 : 36). In each case the solvent was allowed to move 23 cm. Papers were dried between development in a current of air. Finally the papers were sprayed with Folin and Ciocalteau's[2] reagent and kept in darkness for 4 hr. at 25° C. I find that this reagent gives a characteristic colour with gibberellic acid.

When gibberellic acid, melting point 232–233·5° C. (decomposition), supplied by Imperial Chemical Industries, Ltd., was resolved in each of the above solvent systems and the chromatograms sprayed with this reagent two bright blue spots appeared as follows: (1) a dense blue spot, $R_F$ value 0·52 in system (*a*) and 0·24 in system (*b*); the material extracted from this position on the unsprayed paper was found to induce a growth response in dwarf

pea plants as described below. (2) a small blue spot, $R_F$ value of 0·04 in system (*a*) and 0·00 in system (*b*); this material from the unsprayed paper was found not to induce a growth response in the dwarf pea test. The lower limit of detection on a two-way chromatogram using this colorimetric test is about 5 μgm.

None of the chromatograms from the tissue extracts described here showed a positive colour response with the reagent. In order to detect the possible presence of gibberellic acid in quantities less than 5 μgm., a bioassay was carried out using dwarf pea seedlings. Dwarf peas (var. Meteor) were planted in moist sand, four in each 14-cm. pot, and grown for seven days under glasshouse conditions. Pots showing uniform growth were selected for treatment. When one drop of a solution of gibberellic acid (1–5 μgm.) in 10 per cent aqueous acetone was applied to the growing tips of such plants a considerable stimulation to growth was observed. This increase over control growth could be readily assessed. The acetone eluates from the different segments of the chromatograms obtained from the plant extracts, each representing a specific zone on the paper, were examined in this test. One drop (about 0·05 ml.) of the acetone solution added to 0·5 ml. of water was applied to the tips of four plants. Measurements of the total height of the plants were taken ten days after the treatment. Results for the acidic fractions are summarized in Fig. 1.

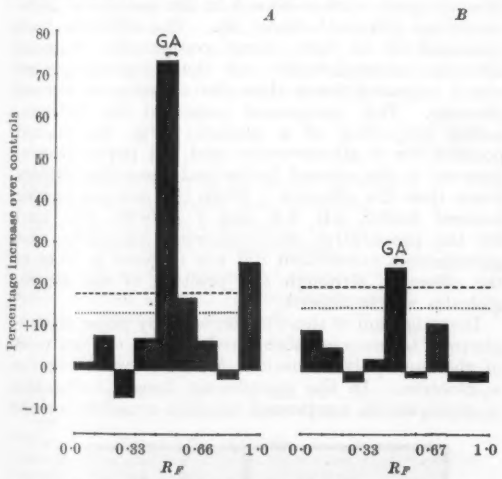


Fig. 1. Bioassay of extracts from wheat seedlings. The growth of dwarf Meteor peas is expressed as percentage increment over control. The increment for control plants treated with 1 μgm. per plant of gibberellic acid (G.A.) is 470. *A*, Extract from basal portion of wheat seedling shoots; *B*, extract from tips of wheat seedling shoots. Significant difference from control: – – –, ($P = 0·01$); ...., ($P = 0·05$)

It will be noted that a highly significant activity was found in the extract obtained from the basal region of wheat seedlings and that some activity was found in the extract from the tips of seedling shoots. Furthermore, the activity observed from the wheat extracts is seen to be associated with the gibberellic acid area of the chromatogram. In addition, there is an area of activity at, or near, the solvent front in the extract from the basal portion of the wheat seedling shoot.

Since the growth response corresponding to the region $R_F$ 0·44–0·56 of the wheat seedling chromatograms was very considerably less than that obtained with 1 μgm. of gibberellic acid, it is not surprising these chromatograms gave a negative test with the Folin and Ciocalteau's reagent. The results presented here, however, provide evidence that gibberellin-like materials occur naturally within the tissues of wheat seedlings.

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## Possible Use of Synthetic Surface-active Agents for the Preparation of Tumour Cell Nuclei

While the observation has been made that surface-active agents will produce lysis of the plasma membrane of cells[1,2], little use seems to have been made of this observation for the preparation of nuclei[3]. Some preliminary observations suggest that nuclei may be prepared in large numbers from a variety of cells, without the use of special apparatus, by treatment with the anionic surface-active agent, sodium lauryl sulphate. Nuclei prepared in this manner are at least as free from cytoplasm as those prepared by the method of Hogeboom *et al.*[4]. In the case of some tumours, such as the *V*–2 carcinoma of the rabbit, they are very much cleaner (Figs. 1 and 2).

Suspensions of tumour cells have been prepared from frozen and fresh tumour by light grinding in a porcelain mortar in 5 volumes of 0·15 *M* saline. The suspensions were filtered successively through No. 80 gauze and 80- and 120-mesh wire screens. The tumour cell suspensions were stirred on ice and 0·4 per cent sodium lauryl sulphate, at room temperature, in 0·15 *M* saline (*p*H 6·9) added. Small drops were removed periodically for observation by phase-contrast microscopy. At concentrations of the surface-active agent of approximately 15 to 20 × $10^{-4}$ *M* most of the nuclei were free from cytoplasm. Small wisps may adhere to some nuclei when certain tumours are treated. When an optimum freeing of nuclei has been observed, these may be recovered by centrifugation and washing in 0·15 *M* saline. Similar results may be obtained by substituting 0·25 *M* sucrose for the 0·15 *M* sodium chloride.

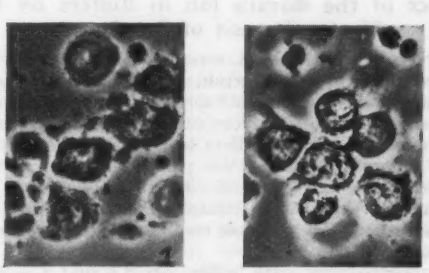

Fig. 1. Fragmented cells of *V*–2 rabbit carcinoma after treatment in glass tube homogenizer with 'Teflon' pestle; method of Hogeboom *et al.* (ref. 4). (× 500)

Fig. 2. Crude preparation of nuclei of *V*–2 carcinoma cells. Prepared in saline and sodium lauryl sulphate. (× 500)

Lysis of cells of *V*–2 carcinoma of the rabbit seems to proceed in several steps: swelling of cytoplasm, rupture of the cell membrane, fragmentation of the cytoplasm, freeing of the nuclei, and finally extraction of the nuclear nucleoprotein. This latter step occurs at a concentration of approximately $31 \times 10^{-4}$ *M* (ref. 5), and results in nuclear ghosts. The nuclei so prepared meet the criteria of Philpot and Stanier[6], namely, intact membranes without blebs, no clumping, intact nucleoli, normal granularity, and extractability of highly polymerized deoxyribonucleic acid. It is realized that morphological criteria may not be sufficient indications of the functional integrity of the nuclei. Biological experiments attempting to elucidate this point are under way. So far most work has been with the *V*–2 carcinoma, but nuclei have also been prepared from the Ehrlich ascites tumour, spontaneous mammary carcinoma of the mouse, and mouse lymphoma.

Experiments with the cationic detergent cetyl trimethylammonium bromide and the non-ionics 'Tween 80' and 'Triton *X*-102' have resulted in cytolysis but have not caused freeing of the nuclei. The non-ionic 'Triton *X*–45' and anionics sodium 2,4- and 2,5-dimethylbenzene sulphonate have occasionally caused the appearance of free nuclei, but not in sufficient number for preparative purposes. Experiments are in progress utilizing other anionic detergents containing the sulphate group and with non-ionic and cationic agents containing a lauryl side-chain.

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## Effect of the Borate Ion in Buffers on the Electrophoresis of Rat Serum

It has recently been reported that the electrophoretic mobility of certain protein components of human[1,2], bovine and rat[3] sera are altered in buffers containing borate. A more extensive investigation of the effect of borate buffers has been carried out in this laboratory during the past two years, during work on the transport of vitamin A alcohol in rat serum (Garbers, C. F., Gillman, H., and Peisach, M., unpublished work). These results are briefly recorded here.

A borate–phosphate buffer, *p*H 8·6 and $I = 0{\cdot}05$, was used for the preparative electrophoretic separation of rat serum proteins on partially acetylated cellulose powder columns[4,5]. A protein component migrating faster than the albumin during electrophoresis was observed (Fig. 1). Fractions 6–18, forming the albumin peak were analysed in the analytical ultracentrifuge ('Spinco' Model *E*). The albumin peak consisted of at least three components, namely, albumin, macroglobulin and the third component which migrated faster than the albumin on electrophoresis. This component possessed the sedimentation properties of a globulin (Fig. 2), stained positive for a glycoprotein[6] and, on paper electrophoresis in the veronal buffer had a mobility slightly lower than the albumin. When the non-complexing veronal buffer, *p*H 8·6 and $I = 0{\cdot}05$, was used for the preparative electrophoretic separation, this glycoprotein component did not migrate in front of the albumin, although the position of the macroglobulin was unaltered.

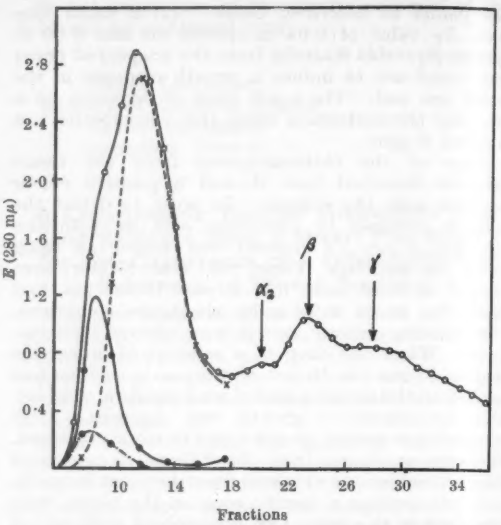


Fig. 1. Eluate from electrophoretic separation on a cellulose powder column (2 × 32 cm.) of rat serum proteins (3 ml.) using the borate–phosphate buffer, *p*H 8·6, *I* 0·05. —○—○—, total protein; —×—×—, albumin; —●—●—, $\alpha_1$-glycoprotein; -.-●-.-●-.-, macroglobulin

Investigation of this phenomenon by paper electrophoretic techniques established that, in the rat, most of the mucopolysaccharides are associated with the $\alpha_1$-globulin. In the complexing borate buffer this $\alpha_1$-glycoprotein component acquires a mobility which

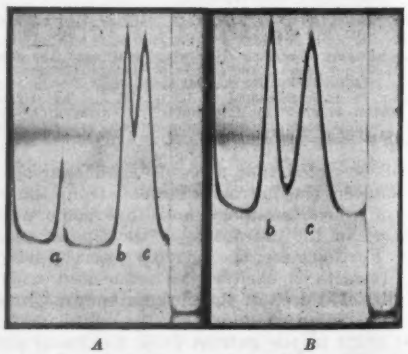


Fig. 2. Sedimentation boundary diagrams of the combined fractions 9 and 10 in borate–phosphate buffer. Speed 59,780 rev./min. *A*, 32 min. after reaching top speed; *B*, 72 min. after reaching top speed. *a*, Macroglobulin; *b*, glycoprotein; *c*, albumin

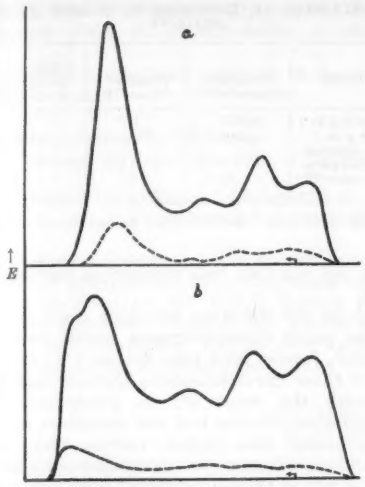


Fig. 3. Diagrams obtained after the electrophoresis of rat serum at *p*H 8·6, *I* 0·05. *a*, Veronal buffer; *b*, borate–phosphate buffer. ——, Stained for proteins (bromophenol blue); – – –, stained for glycoproteins

is greater than that of the albumin, whereas in the non-complexing veronal buffer its mobility is less than that of the albumin (Fig. 3).

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## Formation of Activated Amino-Acids by Intact Cells of *Azotobacter vinelandii*

It has been shown[1–4] that various preparations of enzymes which activate amino-acids convert them into a form which is adsorbed on charcoal, is unstable to alkali, and which reacts with hydroxylamine to form amino-acid hydroxamates. These 'activated' amino-acids seem to be amino-acid-polynucleotide compounds[1–4], and have been suggested[4] as intermediates in protein synthesis, because the amino-acid of such compounds is incorporated into the protein of isolated microsomes. Activated amino-acids have been formed only in cell-free preparations, and it is of considerable interest to determine whether similar compounds are formed by intact cells.

Cells of *Azotobacter vinelandii* were suspended in 0·1 *M* *tris*-(hydroxymethyl)-aminomethane buffer (*p*H 7·25) containing 0·5 μc. of glycine or leucine labelled with carbon-14. After varying periods of time, the temperature of the suspension was reduced to 1° C., and the cells were broken by sonic vibration. Cellular debris was removed by centrifuging at 30,000*g*. Protein was precipitated from the supernatant solution with 6 per cent perchloric acid and isolated as described previously[5]. 1 gm. of charcoal was stirred into each 10 ml. of the perchloric acid extract. The charcoal was collected by centrifugation, washed twice with 0·05 *M* potassium phosphate, and twice with 0·1 *M* potassium acetate. Control experiments demonstrated that this washing removes all free glycine or free leucine from the charcoal. The charcoal, however, contains considerable amounts of bound glycine or leucine. If the charcoal is extracted with 0·2 *M* hydroxylamine, the glycine or leucine is removed as glycine- or leucine-hydroxamate. These substances migrate on paper chromatography along with authentic samples of the respective hydroxamates. The amino-acids, therefore, are apparently bound by their carboxyl groups to some substance which is adsorbed by charcoal. At 25° C., the 'amino-acid-*X*' is stable for at least 6 hr. at *p*H 7, but is degraded, with the liberation of free glycine, at higher *p*H values. For example, it has a half-life of about 60 min. at *p*H 8, and of 20 min. at *p*H 9. The amino-acids are not bound as an artefact due to sonic vibration, as cells disrupted by an osmotic technique[6] also contain glycine adsorbable on charcoal.

Table 1. Incorporation of Glycine labelled with Carbon-14 into Protein and Glycine-*X* of *Azotobacter vinelandii*

| Time (sec.) | Counts per min. per mgm. | |
|---|---|---|
| | Glycine-*X* | Protein |
| 0 | 0 | 0 |
| 5 | 205 | 0 |
| 15 | 278 | 0 |
| 30 | 305 | 9 |
| 120 | 318 | 28 |
| 300 | 413 | 117 |
| 900 | 505 | 311 |
| 3,600 | 486 | 3,300 |
| 900 (plus $6 \times 10^{-4}$ *M* chloramphenicol) | 710 | 180 |
| 900 (plus $10^{-3}$ *M* cobalt ions) | 550 | 215 |

Table 1 presents the time course of incorporation of glycine labelled with carbon-14 into protein and into the charcoal-adsorbable fraction of *Azotobacter* cells. Detectable amounts of labelled glycine cannot be found in protein until at least 30 sec. after the cells have been placed in the labelled glycine solution. In contrast, the fraction adsorbable on charcoal has incorporated considerable amounts of glycine within 5 sec. Table 1 also shows that both chloramphenicol and cobalt ions, which are inhibitors of protein synthesis, enhance slightly the incorporation of glycine into 'glycine-*X*'.

The various properties of this material resemble the properties of the activated amino-acids reported by other investigators, and suggest that intact cells

incorporate amino-acids into some activated form which is at least similar to that obtained in cell-free preparations. The activated glycine obtained from *Azotobacter* cells does, however, differ from other preparations in that it is not precipitated by ethanol from a phenol extract by the method of Kirby[7]. It may be that the amino-acids are not bound to polynucleotide in intact cells, or they may be bound to a rather small polynucleotide. Determination of the exact nature of these amino-acid compounds and their relationship, if any, to cellular protein synthesis requires further investigation.

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## Formation of Phosphoserine from 3-Phosphoglycerate in Higher Plants

Studies with carbon-14 dioxide in plants have indicated that serine may be formed from glycine[1,2], and previous results from this laboratory[3] have shown that serine and glycine are interconvertible in plant tissues. However, other studies[4,5] have indicated that serine may be formed before glycine, and this communication presents evidence that serine may be formed *via* phosphoserine from phosphoglycerate, a pathway previously demonstrated in animals[6].

D-3-Phosphoglycerate-$^{32}$P was prepared by a modification of the method of Neuberg and Lustig[7]. The purity of the compound was established by chromatography and the chromatographically pure compound was eluted from the paper. The enzyme system was prepared from 8–10 day old pea epicotyls (110 gm.) grown in the dark, by grinding with sand and phosphate buffer (0·2 *M*, *p*H 7·4, 200 ml.). The homogenate produced was strained through linen and centrifuged until it was clear. Solid ammonium sulphate was added to 80 per cent saturation, and the suspension was centrifuged at 30,000*g* for 10 min. The precipitate was dissolved in 10 ml. of the above buffer and dialysed against 2 l. of 0·05 *M* phosphate buffer (*p*H 7·4). All operations were carried out at 2°.

The enzyme (1·0 ml.) was incubated with D-3-phosphoglycerate-$^{32}$P (5 μmoles), diphosphopyridine nucleotide (3 mgm.), L-glutamate (25 μmoles), pyridoxal phosphate (0·05 μmole), and phosphate buffer (1·0 ml., 0·2 *M*, *p*H 7·4), in a total volume of 2·5 ml. for 2 hr. at 37° C. The reaction was stopped by addition of absolute ethanol to a final concentration of 50 per cent, and the precipitated protein was spun down and discarded. A control experiment in which the reaction was stopped at zero time was included.

Table 1. Synthesis of Phosphoserine-$^{32}$P from Phosphoglycerate-$^{32}$P

| Experiment | Phosphoglycerate-$^{32}$P | Phosphoserine-$^{32}$P | Unidentified (*C*) (phosphoserine-$^{32}$P) |
|---|---|---|---|
| Zero time (c.p.m.) | 10,900 | 0 | 0 |
| 2 hours (c.p.m.) | 8,400 | 670 | 190 |
| 2 hours (percentage initial phosphoglycerate-$^{32}$P) | 77 | 6 | 1·7 |

Incubation as in text. Radioactivity measurements corrected for decay.

1·5 ml. of the resulting solutions were applied as streaks to paper chromatograms which were run in ethyl ether, formic acid (60 : 40) at 2°. Autoradiographs of these chromatograms showed that a compound with the same $R_F$ as phosphoserine was formed after incubation but was absent at zero time. This compound was eluted, carrier phosphoserine added, and placed as a spot on a paper chromatogram which was run in phenol saturated with water–formic acid (96 : 4). Phosphoserine was detected by spraying with ninhydrin, and the radioactivity found to coincide with this area (*A*, Fig. 1). Marker spots of phosphoserine were placed on the paper and similarly sprayed with ninhydrin. The action of ninhydrin on phosphoserine produces phosphoglycolaldehyde. The paper was then run in the other direction with *t*-butanol, water, picric acid (80 : 20 : 2 v/v/w). An autoradiograph showed the presence of two radioactive compounds. The compound with the lower $R_F$ (*B*, Fig. 1) had the same $R_F$ (0·5) as the marker phosphoglycolaldehyde, formed from carrier phosphoserine and was found to coincide exactly with the radioactive area. The faster running radioactive compound (*C*, Fig. 1) has not been identified, but

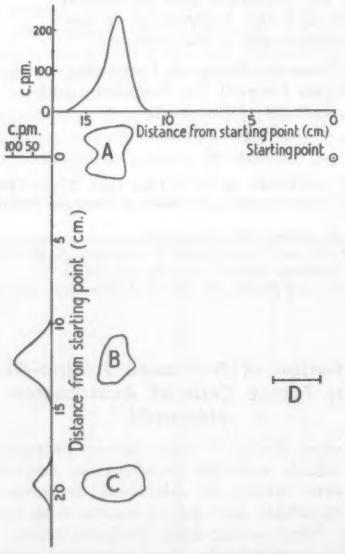


Fig. 1. Identification of phosphoserine-$^{32}$P formed from D-3-phosphoglycerate-$^{32}$P. *A*, Phosphoserine-$^{32}$P; *B*, phosphoglycolaldehyde-$^{32}$P; *C*, unidentified; *D*, $R_F$ of phosphoglycolaldehyde. Chromatogram run in: horizontal, phenol saturated with water–formic acid (96 : 4); vertical, *t*-butanol, water, picric acid (80 : 20 : 2 v/v/w).

may be an isomer of phosphoglycolaldehyde[6]. The quantitative yield of phosphoserine is shown in Table 1.

The individual reactions involved in the synthesis of phosphoserine :

D-3-Phosphoglycerate + DPN$^+$ ⇌
phosphohydroxypyruvate + DPNH + H$^+$

Phosphohydroxypyruvate + L-glutamate ⇌
phosphoserine + α-oxo-glutarate

have been demonstrated, and the specificity and properties of the enzymes are under investigation.

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## Effect of Copper on Growth and Catalase Levels of *Corcyra cephalonica* St. in Zinc Toxicity

The work of Smith and Larson[1], van Reen[2] and van Reen and Pearson[3] has revealed that the dietary ingestion of toxic levels of zinc results in a marked inhibition of growth and deranged iron metabolism in rats. The latter effect was reflected in anæmia and decreased levels of liver catalase and cytochrome oxidase. Liver extract partially counteracted the growth inhibition, while minute supplements of copper to the toxic diet reversed the anæmic condition[1] and restored the levels of the iron enzymes[3]. From such results it has been concluded that the inhibition of growth is unrelated to the enzymic changes observed, and that the two phenomena are distinct and different effects of zinc toxicity in the animal organism.

In view of our earlier studies on zinc toxicity in the larvæ of the rice moth, *Corcyra cephalonica* St.[4], it was thought of interest to investigate the zinc–copper relationship from this point of view. For this purpose, groups of 10–15 day-old larvæ, weighing between 7·0 and 9·0 mgm. per ten, were grown for a period of three weeks on the following diets : (1) control, basic diet of sieved wheat flour ; (2) zinc toxic-basal diet plus 0·4 per cent $ZnSO_4,7H_2O$ ; (3) zinc toxic diet as in (2) with graded amounts of $CuSO_4,5H_2O$ ; and (4) zinc toxic diet supplemented with 1·0 per cent liver extract. The last group, namely, that with liver extract, was included for purposes of comparison with earlier work[1–4]. The experimental procedure involved in the preparation of the liver extract and the rearing of the larvæ has been described in detail elsewhere[4]. Growth was recorded at weekly intervals. At the end of three weeks, larvæ from each group were weighed and homogenized in *M*/15 phosphate buffer (*p*H 7·0). Catalase activity was determined by allowing aliquots of the buffer extract to act upon 0·05 *M* hydrogen peroxide and titrating the unreacted hydrogen peroxide, at the end of the reaction period, with *N*/100 potassium permanganate, according to the procedure of Ramachandran and Sarma[5]. Catalase activity was expressed as ml. of *N*/100 permanganate consumed per gm. of larval tissue per minute. The results obtained in a typical experiment are shown in Table 1.

Table 1. Influence of Copper on Zinc Toxicity in Rice Moth Larvæ

| No. | Supplements to basal diet (10 gm. sieved wheat flour)* | Weight of 10 larvæ (mgm.) | | | | Catalase units |
|---|---|---|---|---|---|---|
| | | At transfer | 1st week | 2nd week | 3rd week | |
| 1 | Control (no zinc) | 7·7 | 38 | 105 | 226 | 493·2 |
| 2 | None | 8·3 | 22 | 57 | 100 | 309·1 |
| 3 | 0·005 per cent copper sulphate | 7·0 | 23 | 56 | 103 | 393·6 |
| 4 | 0·01 per cent copper sulphate | 8·2 | 22 | 59 | 98 | 540·6 |
| 5 | 1·0 per cent liver extract | 6·0 | 31 | 94 | 194 | 315·5 |

* Unless otherwise stated, all diets also contained 0·4 per cent zinc sulphate.

It can be seen that the intake of toxic amounts of zinc brings about not only an inhibition of growth but also a pronounced fall in tissue catalase activity. 0·01 per cent copper sulphate, added to the zinc-toxic diet, restores the enzyme levels without, however, improving growth to any extent. Sivarama Sastry, Radhakrishnamurty and Sarma[4] have recently shown that this growth inhibition can be considerably reversed by the inclusion of liver extract in the toxic diet. The results presented in Table 1 show that liver extract has little effect on catalase activity, however.

These results indicate that the inhibition of growth and in catalase activity are separate effects of zinc toxicity in the insect organism, as in the rat[1,3], and point to the probable multiplicity of metabolic disturbances involved in zinc toxicosis. Since it is well known that catalase level in animal tissues is decreased by either an iron or copper deficiency[6] and that copper influences iron metabolism[7], it is likely that the antagonistic behaviour of zinc and copper brought out by the present investigation is a reflexion of an adverse effect of zinc on iron metabolism in the larvæ. It is also possible that such an interference with iron metabolism is a common phenomenon in zinc toxicosis.

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## Effect of Nicotinic Acid on the Cholesterol Contents of Rat-Livers

Lowering of the blood cholesterol level by means of large doses of nicotinic acid has been described by Altschul[1], and this effect has been confirmed by others[2]. This effect is caused by nicotinic acid only and its mechanism has not yet been clarified. The use of the amide of the nicotinic acid is said to be without effect.

Table 1

| Percentage nicotinic acid in diet | No. of rats | Liver content: Total cholesterol (mgm. per cent) | P | Total lipids (per cent fresh weight) |
|---|---|---|---|---|
| 0 | 8 | 1,181·5 | | 25·0 |
| 1 | 10 | 1,038·3 | < 0·5 | 30·8 |
| 2 | 10 | 923·3 | < 0·2 | 31·0 |
| 3 | 10 | 683·7 | < 0·01 | 24·4 |
| 4 | 10 | 634·1 | < 0·01 | 25·2 |
| Normal diet (*C*) | 10 | 220·0 | | 5·0 |

50 Sprague–Dawley rats (male), ranging in weight from 110 to 120 gm., were fed for 21 days on a special hypolipotropic diet free from cholesterol. This caused an endogenous fatty liver of the cholesterol type (group *A*) (unpublished work). Another group received the same diet but with nicotinic acid in increasing amounts, namely, 1, 2, 3 and 4 per cent (group *B*). A third group (*C*) was fed a normal diet. All animals were killed at the end of this experiment under light ether anæsthesia; after exsanguination the livers were processed according to Sperry's method, and total lipid[3] and cholesterol contents were determined. The results are given in Table 1. Increased cholesterol contents were found in the livers of the animals fed the special diet, the content in group *A* (without nicotinic acid) being six times as great as that in group *C* (normal diet). Liver cholesterol decreased with increasing nicotinic acid in the special diet, but 4 per cent nicotinic acid did not reduce the cholesterol level to its normal value. Nicotinic acid, *per se*, tends to produce fatty degeneration of the liver[4] and intolerably large doses may be necessary to bring the liver cholesterol produced by the special diet to its normal level.

This antilipotropic effect of nicotinic acid can be interpreted as due to the demand of its detoxication products for methyl groups. Detoxication may occur via nicotinic acid, which needs coenzyme A for synthesis. It is suggested, therefore, that this effect is caused by infiltrative fattening of the liver and reduced synthesis of cholesterol (relative lack of coenzyme A).

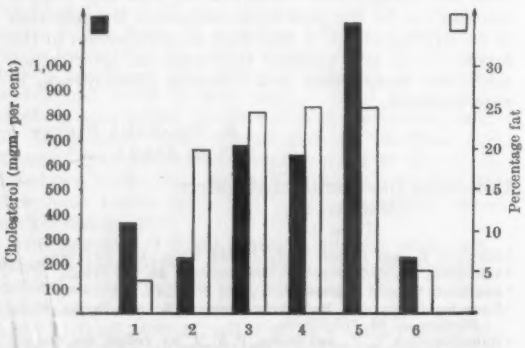


Fig. 1. Cholesterol and fat contents of rat livers after feeding the special diet with (1) 2 per cent α-phenylbutyric acid, (2) 2 per cent α-diphenylylbutyric acid, (3) 3 per cent nicotinic acid, (4) 4 per cent nicotinic acid, (5) control group *A*, (6) normal diet, group *C*

Altschul[1] explained the lowering of the level of cholesterol in the blood by nicotinic acid as due to increased oxidative catabolism of cholesterol. Merill[5], working with rabbits, has suggested possible detoxication products of nicotinic acid, but his work has not afforded clear proof of the inhibition of acetylation *in vivo*. Recent investigations *in vitro* have demonstrated inhibition of acetylation[6], but such experiments *in vitro* cannot establish the influence of nicotinic acid on synthesis of cholesterol.

Comparison investigations using α-phenylbutyric acid and α-diphenylylbutyric acid has led to the following suggestions (Fig. 1): (1) that synthesis of cholesterol is decreased by the influence of nicotinic acid, and (2) that a relative lack of coenzyme A is the causative mechanism.

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## Effect of Splenectomy on the Phagocytic Activity of the Reticulo-Endothelial System

The reticulo-endothelial system comprises groups of cells situated in various parts of the body having the ability to take up particulate and colloidal matter. The cells of this system, which have an intimate relationship with the circulation, are to be found mainly in the liver and spleen, from which organs about 95 per cent of intravenously injected particulate material may be recovered[1] and of this amount we have found in mice that the spleen contains less than 5 per cent.

It is generally recognized that the macrophages of the splenic sinusoids play an important part in various physiological and pathological processes. It has been shown by Nicol *et al.*[2] that prolonged œstrogenic stimulation appeared not only to produce a greater formation and activation of reticulo-endothelial cells in the spleen but also assisted their mobilization and liberation into the circulation. This might, therefore, suggest that the importance of the spleen in phagocytic activity is not adequately reflected by the small amount of injected particulate or colloidal matter which is to be found in that organ. The present investigations were planned to ascertain the effect of splenectomy on the rate of removal of particulate matter from the circulating blood.

The following experiments were carried out on 70 male white mice (*T.O.* Swiss strain) of 20–25 gm. body-weight. The phagocytic activity was measured by the rate of disappearance of a known amount of carbon from the circulating blood, as described in a

recent communication[3]. The total body phagocytic activity or phagocytic index is denoted as previously by the symbol $K$.

Twenty-five of the animals were used as controls. They were given carbon only and showed an average phagocytic index or $K$ value of $26 \pm 4{\cdot}8$. The remainder of the animals were divided into two groups and treated as follows. Group I: Twenty-seven mice were splenectomized, the spleen being removed through a left subcostal incision under open-ether anæsthesia. The incision was closed in two layers using fine silk. The animals made an uneventful recovery and appeared to be little affected by the operative procedure. Group II: Eighteen animals were subjected to a left subcostal incision, the spleen being examined but not removed and the wound being closed as in Group I.

In both groups the phagocytic index was then assessed for batches of three animals at varying times from 6 hr. to 8 days after the operation. The results are shown in Table 1. It can be seen that, in the splenectomized animals, 6 hr. after the operation there is marked depression of phagocytic activity, the phagocytic index being reduced to $K = 8$, and that recovery to within normal limits occurs in about 4 days. In the animals subjected to a similar operation in which the spleen was not removed (mock splenectomy) the phagocytic activity also becomes depressed after 6 hr. but to a lesser extent than in the splenectomized animals, and recovery to normal limits takes about 7 days.

Table 1. Effect of Splenectomy and 'Mock Splenectomy' on the Phagocytic Activity of the Reticulo-Endothelial System

| Time following operation | Phagocytic index ($K$ value) | |
|---|---|---|
| | Group I Splenectomized animals | Group II 'Mock splenectomized' animals |
| 6 hr. | 8 | 13 |
| 1 day | 10 | 10 |
| 2 days | 13 | |
| 3 days | 12 | 12 |
| 4 days | 20 | 12 |
| 5 days | 23 | |
| 6 days | 25 | 16 |
| 7 days | 29 | 23 |
| 8 days | 22 | |

Phagocytic index for 25 control animals not undergoing operation, $26 \pm 4{\cdot}8$.

The results show that after splenectomy there is marked depression of phagocytic activity for about 4 days and this appears to be chiefly the effect of the anæsthetic and operative procedure. The speedier recovery of phagocytic activity in the splenectomized animals to within normal limits is probably due to the compensatory action of the liver, but experiments of several months duration may be necessary to confirm this.

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## Infectivity of Ribonucleic Acid from Mice and Tissue Culture infected with the Virus of Foot-and-Mouth Disease

Several workers[1-5] have recently reported the preparation of infective ribonucleic acid from tissues or tissue cultures infected with animal viruses, using the phenol method described by Gierer and Schramm[6] for tobacco mosaic virus. In this laboratory, ribonucleic acid prepared by the same method from pig kidney tissue cultures infected with the virus of foot-and-mouth disease (strain 997—Waldmann type *C*) has been shown (*a*) to induce cytopathic effects in pig kidney cell monolayer cultures, (*b*) to paralyse and ultimately kill unweaned mice if administered intramuscularly, and (*c*) to yield in tissue culture and in mice virus of the same immunological type as the original strain (complement fixation and serum neutralization tests).

Although direct evidence is still lacking, the following observations are regarded as pointing to the absence of residual virus from the preparations. Treatment of the preparations either with ribonuclease (at a concentration of 10 μgm./ml.) or with normal guinea pig serum abolishes their infectivity for mice and for tissue cultures, whereas the virus is unaffected by these treatments. None of the ribonucleic acid preparations so far examined has been infective when inoculated intraperitoneally into mice although the virus is highly infective when inoculated by this route. Skinner, at this Institute, has shown that intramuscular inoculation of virus into unweaned mice gives an end point higher than that obtained by intraperitoneal inoculation. For strain 997 we have found in three experiments that this difference is about 0·4–0·7 log unit, comparable with that found by Skinner for some other strains. This difference would at first suggest that the infectivity of the ribonucleic acid (inoculated intramuscularly) might be due to residual virus which would not be detected by the intraperitoneal route, since in general the ribonucleic acid prepared from pig kidney tissue culture fluids with a virus titre of $10^{4\cdot5}$ *ID*50 0·03 ml. (intraperitoneal inoculation of unweaned mice) had a 50 per cent end point dilution of $10^{-0\cdot5}$ (intramuscular inoculation). That this is not so is indicated by the following experiments. A concentrate of pig kidney tissue culture fluid prepared by precipitation with ammonium sulphate which contained $10^{6\cdot0}$ *ID*5) 0·03 ml. (intraperitoneal inoculation of unweaned mice) and $10^{8\cdot3}$ *ID*50 ml. (titration in pig kidney cell monolayers) gave a ribonucleic acid preparation which was non-infective intraperitoneally but killed mice at a dilution of 1/10 inoculated intramuscularly and infected pig kidney cell monolayer cultures at a dilution of 1/100. In another typical experiment 0·3 ml. of the ribonucleic acid failed to infect any of 10 mice inoculated intraperitoneally whereas 0·03 ml. of the same preparation killed all of 10 mice inoculated by the intramuscular route.

Infection of the kidney cells and the mice with ribonucleic acid led to the production of apparently complete virus. This virus was neutralized by type specific guinea pig antiserum but not by normal serum.

Some experiments have also been done with a neurotropic strain of the virus[7,8]. This virus, which is type *A* (complement fixation test), regularly infects adult mice when inoculated intracerebrally. The ribonucleic acid prepared from the brains of such

infected mice was infective for mice by the intracerebral route. If the ribonucleic acid preparation was first treated with ribonuclease it was non-infective. The harvested brains from the animals infected with the ribonucleic acid preparation were fully infective for mice by intracerebral inoculation and fixed complement with type *A* guinea pig antiserum.

We wish to thank Mr. H. H. Skinner for carrying out some of the experiments with the neurotropic strain and Dr. F. K. Sanders for discussions and many helpful suggestions.

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## Change in Oxygen Consumption of the New-Born Pig with a Fall in Environmental Temperature

The oxygen consumption of the new-born pig during the first day of life increases[1] to the extent of approximately 1 ml. oxygen/kgm.min. per 1° C. fall in environmental temperature over the range 38–20° C. The mean level of oxygen consumption rises between the first and second days, and the inverse relation between metabolism and temperature is maintained[2]. It is therefore of interest that Holub, Forman and Ježková have reported[2] the absence of an increase in the metabolism of pigs from three to six days of age when the environmental temperature is lowered from 23° to 3° C. Observations have now been made on an experimental pattern similar to that adopted by those authors on pigs from birth to six days of age. The results obtained fail to confirm those of Holub *et al.*; indeed, there was a marked rise in oxygen consumption in every case when the temperature of the surroundings fell from near 23° C. to approximately 3° C.

18 Large White pigs, of both sexes and taken from six litters, were used in these experiments; six were less than 1 day old, including two which had not been suckled by the sow (weight range: 1·07–1·40 kgm.), six were 2–4 days old (weight range: 1·15–1·72 kgm.) and six were 5–6 days old (weight range: 1·56–2·72 kgm.). They were born in a farrowing house (general air temperature: 7–15° C.) fitted with creeps heated by infra-red lamps. Consumption of oxygen at both environmental temperatures was measured by spirometer, in a closed circuit system with continuous removal of carbon dioxide. The consumption was measured for individual pigs first in the region of 23° C., then at 3° C., then again at 23° C. Measurement periods were never less than 30 min., and were always preceded by an equilibration period of 10–15 min. in either chamber. Omission of an adequate equilibration period gave spuriously low figures for the consumption of oxygen, due to the unreliability of readings of air temperature taken within the first few minutes after the closing of the chamber. Rectal temperatures were recorded four times for each pig, that is, before each measurement period and at the end of the experiment.

Table 1. Oxygen Consumption of New-Born Pigs in the First Week of Life at Environmental Temperatures of Approximately 23° and 3° C. Six Pigs in Each Age Group

| Age | Environmental temperature (°C.) Mean ± S.E. | Oxygen consumption (ml. dry gas at S.T.P./kgm. min.) Mean ± S.E. |
|---|---|---|
| Under 1 day | 22·8 ± 0·4<br>3·1 ± 0·1<br>22·2 ± 0·1 | 21·6 ± 1·1<br>34·5 ± 1·1<br>24·9 ± 1·0 |
| 2–4 days | 23·3 ± 0·9<br>3·8 ± 0·9<br>23·0 ± 0·2 | 25·7 ± 0·9<br>38·8 ± 0·9<br>26·0 ± 0·6 |
| 5–6 days | 24·1 ± 0·6<br>5·0 ± 0·5<br>23·6 ± 0·5 | 22·7 ± 0·6<br>35·9 ± 1·2<br>22·9 ± 1·0 |

In every case the consumption of oxygen was considerably greater at 3° than at 23° C.; contrary to the findings of Holub *et al.*, in no case did the consumption fall or remain at the same level with exposure to the lower temperature. The results for three groups of pigs are given in Table 1. The average figures for oxygen used were 23·3, 36·4 and 24·6 ml./kgm.min. for the three succeeding periods at average temperatures of 23·4°, 3·9° and 22·9° C., respectively, and the differences between consumptions at the two temperatures are highly significant for all three age-groups.

The rectal temperature changes are given in Table 2. The fall was most marked in the youngest group at 3° C., but even here considerable recovery took place during the third measurement period, at 23° C. At 5–6 days of age, rectal temperature did not change during the period at 3° C.

Table 2. Initial Rectal Temperatures of New-Born Pigs and Changes Occurring During each Period of Measurement. Six Pigs in Each Age Group

| Age | Initial rectal temperature (°C.) Mean ± S.E. | Rectal temperature changes during 1st period (°C.) Mean ± S.E. | 2nd period (°C.) Mean ± S.E. | 3rd period (°C.) Mean ± S.E. |
|---|---|---|---|---|
| Under 1 day | 38·6 ± 0·1 | −0·4 ± 0·1 | −1·7 ± 0·3 | 0·9 ± 0·2 |
| 2–4 days | 39·1 ± 0·2 | −0·3 ± 0·02 | −0·6 ± 0·2 | 0·2 ± 0·2 |
| 5–6 days | 39·5 ± 0·3 | −0·4 ± 0·1 | 0 ± 0·1 | −0·2 ± 0·1 |

Thus these results show a vigorous response from the new-born pig to lowering of the environmental temperature, in contrast with the absence of response found by Holub *et al.* under similar conditions, and using the same breed of pig. Moreover, this response occurred with pigs, down to 1 hr. of age, which had not been suckled previously by the sow, whereas the youngest animals used by Holub *et al.* were 3 days old. The type of response in respect of oxygen consumption reported here for new-born pigs was not found by Holub *et al.* in pigs younger than 9–10 days of age, and the same is approximately true for rectal temperature changes; the changes in rectal temperature for pigs up to 4 days old (Table 1) correspond

generally with those found by Holub *et al.* in pigs aged 10–20 days.

The possibility arises, therefore, that these contrasting results are due to pigs differing constitutionally in their response to lowered environmental temperature. However, before such an outstanding variation among pigs could be accepted, it would be necessary to establish equality of experimental conditions between the two series of experiments.

It is concluded that under the conditions described here the new-born pig responds to a drop in environmental temperature from 23° to 3° C. by a rise in the production of heat of the order of 50 per cent.

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## Ringed Appearance of Lipid Spheres under the Phase-Contrast Microscope

Recently, Chou and Bradbury[1] have pointed out some optical artefacts produced in the appearance of fat droplets under the phase-contrast microscope. They say that homogeneous fat droplets may have a "crescentic" appearance if examined in a non-axial light source or an eccentric condenser. They also point out that in a fully centred system the appearance of such a fat globule is a "perfectly symmetrical sphere with a dark rim or apparent 'cortex' surrounding the bright region within".

A great variety of living cells have been examined in this laboratory[2] under phase-contrast and interference microscopes and it has been often observed that a non-axial phase-contrast system gives the typical "crescentic" appearance to the lipid spheres that occur so commonly in the animal oocytes, gland cells, and neurones. Such an artefact, however, can easily be detected since it invariably causes a great loss in overall contrast, as is quite evident from the photomicrograph *B* in Fig. 1 of Chou and Bradbury[1].

The ringed appearance of fat or lipid droplets in a perfectly adjusted phase-contrast system has, however, led many cytologists to misinterpret the structure of these homogeneous lipid spheres as duplex.

Similarly, students of oogenesis have very commonly described the so-called Golgi bodies (lipid spheres) as duplex vesicles with a dark cortex and a clear medulla, after using such apparently harmless techniques as fresh coverslip preparations treated with osmium tetroxide solution for short periods[3]. These workers were further misled by the exactly similar appearance of these Golgi bodies under the phase-contrast microscope, in the living material, especially in the animal oocytes. Some extensive work in this laboratory on the histochemistry of oocytes has conclusively shown that these Golgi bodies are nothing but homogeneous lipid spheres colouring uniformly with sudan black *B* in ordinary circumstances. The duplex appearance of the lipid spheres of some oocytes in sudan black *B* has no correlation with their duplex appearance either in osmium tetroxide solution or in the living cells examined under the phase-contrast microscope, because, in such cases, the duplex appearance in sudan black *B* is due to the presence of either solid or masked lipids[3]. This appearance can easily be changed by using special techniques. That the duplex appearances of the homogeneous lipid bodies under the phase-contrast microscope are optical artefacts becomes amply clear from the observations on earthworm oocytes and human oral epithelium, described below.

The oocytes of *Pheretima posthuma* have numerous lipid spheres in the cytoplasm besides the mitochondria and some clear vacuoles. There is no yolk. The lipid spheres colour homogeneously, without any clear medulla whatsoever, in sudan black *B* used on gelatin sections of material fixed with formaldehyde-calcium (Fig. 1*a*). In the living oocytes examined under the phase-contrast microscope the larger spheres appear as clear and sharp rings (Fig. 1*b*).

The loose human oral epithelial cells have a number of homogeneous sudanophil lipid spheres of various sizes. The larger ones always have a ringed appearance under the phase-contrast microscope (Fig. 1*c*).

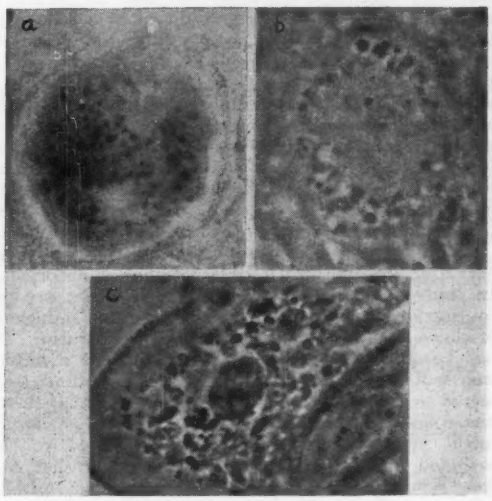


Fig. 1

Some similar observations were also made by Roque[4] on the neurones of the gastropod, *Helix*. These observations clearly show that the duplex or ringed appearance of the lipid spheres under the phase-contrast microscope is an optical artefact.

It may be mentioned that the duplex ringed or crescentic appearance given by the Golgi bodies in the male germ cells (for example, in pulmonate gastropods[4,5]) and certain gland cells (for example, liver cells of *Anadenus*[6,7]) under the phase-contrast microscope are not to be considered artefacts as they have a non-lipid core.

Great care should therefore be taken in interpreting the appearance under the phase-contrast microscope of cell inclusions in general and lipid spheres in particular; these may always be checked carefully using some vigorous lipid colourant like sudan black *B*, as was also pointed out by Baker[8].

Carl Zeiss (West Germany) stand *W* and Leitz 'Dialux' microscopes with phase-contrast systems

were used in this work. Living cells were mounted in Baker's[9] physiological solution.

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## Counting of Sulphate-reducing Bacteria in Mixed Bacterial Populations

In the dilution method of counting *Desulphovibrio* in soil or water, a selective medium containing lactate and inorganic salts is commonly employed. The growth of a sulphate reducer is recognized by the appearance of the black colour of ferrous sulphide. Since the organisms are anaerobes and the medium is simple in composition the addition of a reducing agent is essential. Grossman and Postgate[1] selected cysteine as the most suitable of the reducing substances they examined. Cysteine possesses the disadvantage that it may be attacked with the liberation of sulphide by certain bacteria which do not reduce sulphate. Hence it is necessary to apply some test to confirm the presence of *Desulphovibrio* in cultures which become black. A further disadvantage in the method proposed by Grossman and Postgate is that the cultures are incubated in an anaerobic atmosphere.

Much interest has been taken in the corrosive action on iron for which *Desulphovibrio* is notorious. In contrast, little attention has been given, except by Starkey and Wight[2], to the favourable influence of elemental iron on the growth of the organism. It has been recognized for a long time that metallic iron will lower the oxidation-reduction potential of media to a level suitable for *Clostridia*, and that these anaerobes will multiply readily in tubes of liquid media incubated in air if a strip or rod of iron is included in the medium. This suggested that for the purpose of dilution counts of *Desulphovibrio*, iron, which would not affect the selectivity of a synthetic medium, might be used to provide the necessary reducing conditions. Iron was therefore tested in a medium used by Starkey[3]: sodium lactate, 3·5 gm.; $NH_4Cl$, 1 gm., $K_2HPO_4$, 0·5 gm.; $MgSO_4.7H_2O$, 2 gm.; $Na_2SO_4$, 0·5 gm.; $CaCl_2$, 0·1 gm.; Mohr's salt, trace; and tap water to 1,000 ml.; *p*H 7. The medium was sterilized in quantities of 5–7 ml. in 5/8-in. tubes. Iron was added as a nail 3–5 cm. long and 0·3–0·4 cm. thick, either before or after the tubes of medium were sterilized. Other supplements were sterilized in the medium. All media were used soon after preparation. In examining soil or water a series of decimal dilutions was prepared in sterile physiological saline and 1 ml. of each dilution was transferred to each of five tubes of each medium. Incubation was at 30° C. Anaerobic conditions were provided by pyrogallol and sodium carbonate.

Some typical results are shown in Table 1. Iron appears to be at the least as effective as cysteine in promoting the growth of sulphate reducers, and it possesses an advantage over cysteine in not giving rise to false positive results. A finding which greatly simplifies the technique of counting the organisms is that the iron medium may be incubated in air. More than a hundred trials of this medium have been made comparing aerobic with anaerobic incubation; no definite difference could be detected in the results. If the medium containing cysteine were similarly incubated in air the problem of its selectivity for sulphate reducers would arise. A conclusion which may be drawn, incidentally, from this work is that where iron occurs in soil or water into which oxygen penetrates, *Desulphovibrio* could easily find conditions which permitted its growth and its corrosive action on the iron.

Table 1. Influence of Metallic Iron on Growth of Sulphate-reducing Bacteria

| | Medium | Anaerobic incubation | Number of positive tubes at a dilution of* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ |
| Soil | Starkey's | + | 5 | 0 | 0 | 0 | 0 | 0 |
| | Starkey's + sodium thioglycollate, 0·1 per cent | + | 0 | 0 | 0 | 0 | 0 | 0 |
| | Starkey's + sodium thioglycollate, 0·1 per cent + 'Difco' yeast extract, 0·25 per cent | + | 5 | 0 | 0 | 0 | 0 | 0 |
| | Starkey's + 'Difco' yeast extract, 0·25 per cent + nail | + | 5 | 5 | 5 | 4 | 0 | 0 |
| | Starkey's + nail | + | 5 | 5 | 5 | 4 | 0 | 0 |
| Water | Starkey's + nail | + | 5 | 5 | 5 | 4 | 0 | 0 |
| | Starkey's + nail | − | 5 | 5 | 5 | 4 | 1 | 0 |
| Water | Starkey's + nail | + | 5 | 5 | 5 | 5 | 2 | 0 |
| | Starkey's + nail | − | 5 | 5 | 5 | 5 | 1 | 1 |
| Soil | Starkey's + nail | − | 5 | 5 | 4 | 2 | 0 | 0 |
| | Starkey's + cysteine, 0·1 per cent | + | 5 | 5 | 5 | 1 | 0 | 0 |
| Soil | Starkey's + nail | − | 5 | 5 | 3 | 1 | 0 | 0 |
| | Starkey's + cysteine, 0·1 per cent | + | 5 | 5 | 4(1) | 1(4) | 0(1) | 0 |
| Soil | Starkey's + nail | − | 5 | 5 | 2 | 1 | 0 | 0 |
| | Starkey's + cysteine, 0·1 per cent | + | 5 | 5 | 2(3) | 0(5) | 0(3) | 0 |

* Figures in parenthesis indicate false positive results.

We wish to thank Dr. T. Gibson, of the Edinburgh and East of Scotland College of Agriculture, for helping in the presentation of this communication.

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## *Eichornia crassipes* in the Nile of the Sudan

During an expedition made by the Hydrobiological Research Unit of the University of Khartoum in March and April 1958, *Eichornia crassipes* was encountered in the White Nile and Bahr el Gebel along about 1,000 km. of the river system. Observations were made in part from the Unit's launch (from Khartoum to the Sobat Mouth) and in the southern reaches (from the Sobat Mouth to Juba) from a Sudan Railways steamer. The latter travelled

Table 1. DISTANCES IN KM. UPSTREAM OF KHARTOUM OF PLACES MENTIONED IN THE TEXT. (Compiled from Sudan Almanac, 1956)

| | | |
|---|---|---|
| White Nile | Khartoum | — |
| ,, | Gebel Aulia Dam | 47 |
| ,, | Kosti | 319 |
| ,, | Gebelein | 394 |
| ,, | Geigar | 460 |
| ,, | Malakal | 819 |
| ,, | Sobat Mouth | 844 |
| ,, | Zeraf Mouth | 888 |
| | Lake No (mouth of Bahr el Ghazal) | 964 |
| Bahr el Gebel | Zeraf Cuts | 1,252 |
| ,, | Shambe | 1,372 |
| ,, | Juba | 1,754 |

night and day so the southernmost limit of the plant could not be recorded precisely.

Former members of the Hydrobiological Research Unit, Catholic missionaries in the southern Sudan and many Sudanese whose lives are centred on the river agree that they had not seen the plant prior to the winter of 1957–58. Its spread has therefore been of an explosive nature. Recent detailed examination of the photographs which I took in December 1956 on an expedition to the White Nile and Bahr el Ghazal suggests that it may have been present in one or two stations in the Bahr el Ghazal, but this would require confirmation by further field work.

*Eichornia* occurs either as free-floating mats, as marginally fixed yet floating mats, or as a terrestrial plant of the damp river margins, where it frequently becomes stranded. It reproduces vegetatively by tillers which persist and hold large numbers of individuals together in mats of up to 50 m.², but usually much less. Its height varies from about 8 cm. to about 40 cm. It flowers abundantly, but the part played by such reproduction was not assessed.

At Kosti (see Table 1) *Eichornia* formed a conspicuous part of the floating marginal vegetation and as drift it was found downstream of the town in small quantities. It occurred from here southwards to the approximate vicinity of Shambe, but its status both as a marginal type and as drifting islands varied considerably, and this variation is analysed briefly below. It was particularly abundant in the Kosti–Gebelein and Malakal–Zeraf Mouth reaches. No drift was seen in, or issuing from, the River Sobat or the Bahr el Ghazal, but as the mouth of the Bahr ez Zeraf was passed in the night no observations can be recorded for that river. The Zeraf Cuts (the artificial capture by the Bahr ez Zeraf of part of the waters of the Bahr el Gebel) are downstream of the most southerly occurrence of *Eichornia* so it is extremely likely that the Bahr ez Zeraf also has the plant.

*Eichornia* was more common marginally where the river margin was dominated by various Gramineae, especially *Vossia cuspidata*, which advance into the river irregularly, thus creating bays, at least in the season when the river current is slack. Such situations presumably reduce the drag of the river current upon the comparatively loosely attached *Eichornia* mat and were formerly occupied by ecologically similar types, for example, *Pistia stratiotes*, *Azolla* spp. and *Lemna* spp., which in the reaches where *Eichornia* is present have been more or less eliminated. *Eichornia* appears to be the most successful in the competition for this ecological niche.

Its occurrence in relation to swamp types in part explains its distribution in the river system. (1) Upstream of Shambe the river current is strong and papyrus is usually the marginal type. As this species maintains a fairly simple straight front on to the river there are few niches suitable for *Eichornia*. (2) The Kosti–Gebelein and Malakal–Zeraf Mouth reaches are both where the riverain swamp is well developed in a form allowing the marginal attachment and breeding of the plant. (3) The most downstream occurrence (near Kosti) roughly parallels that of papyrus (which is also dispersed in part at least as drift), and downstream of this station the swamps are of a different character, largely owing to the effect of the Gebel Aulia Dam on the amplitude of the river level.

As for all other free-floating river vegetation the distribution pattern of *Eichornia* drift in the river can be related to at least two factors, namely, a source of supply, and a means of bringing plants into the river[1]. Undoubtedly drifting *Eichornia* was more common in, and immediately downstream of, regions where its marginal development was good, but an example will show that its distribution cannot be simply related to a source of supply. At Geigar one evening *Eichornia* drift was abundant; the following morning it was scarce. It is suggested that local storms, so common in the tropics, are an important means of bringing drift into the river and thus explaining its temporal distribution pattern. During one such storm the strong winds and the wave action so induced on the river were seen to break the attachments of marginal *Eichornia* and release it as drift.

The Nile is of vital importance to the Sudan as a line of communication. Already *Eichornia* drift is constituting a minor nuisance to the Sudan Railways steamers by becoming wedged between the driving unit of the steamer and its barges (which are lashed to either side and fore of the driving unit) thus interfering with water intake for engine cooling. Such a nuisance has arisen in the few months that *Eichornia* has been in the Nile. The Congo and many other tropical rivers are witness to the probable result of its continued explosive development.

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## Chelation or Complex-formation by Indoleacetic Acid *in vitro*

AFTER a long series of attempts to demonstrate chelation or complex-formation between 3-indoleacetic acid and metal ions *in vitro*, which were unsuccessful presumably because of the very low concentrations of indoleacetic acid inevitable in the aqueous solutions used, we repeated the experiments of Cohen *et al.*[1], using, as they did, cupric nitrate and indoleacetic acid in 50 per cent ethanol. Essentially similar results were obtained, except that our value for log $K$ by the Bjerrum method was 3·0 as compared with theirs of 5·4; we were also not entirely satisfied that a discontinuity in our curve for absorption at 360 mμ versus composition occurred at a ratio of 1 copper : 2 indoleacetic acid and there was no indication of a break at 1 copper : 1 indoleacetic acid (*cf.* their Fig. 2).

We also carried out similar experiments with ferric ions, which these authors found to be strongly chelated

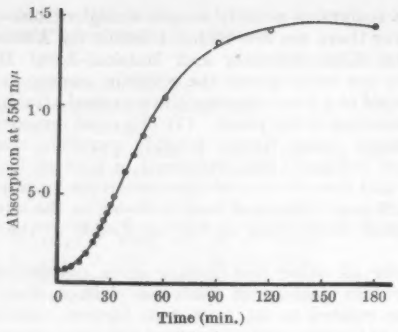


Fig. 1

by 3-indoleacetic acid. The Bjerrum method gave us a value of log $K$ of 6·0. Measurements of absorption spectra for a solution of $4 \times 10^{-3}$ $M$ ferric chloride and $10^{-1}$ $M$ indoleacetic acid in 50 per cent ethanol showed a strong development of colour, especially between 450 and 600 mμ. It was observed, however, that the intensity of the colour in the mixture increased with time, suggesting either that chelation was very slow or that a progressive break-down of indoleacetic acid to some coloured compound was occurring. The development of colour at 550 mμ in a mixture containing $4 \times 10^{-3}$ $M$ ferric chloride and $2 \times 10^{-3}$ $M$ indoleacetic acid (*p*H 2·6) was measured against time and found to reach a maximum after about 2 hr. (Fig. 1).

To investigate the possibility of break-down of indoleacetic acid, ferric chloride ($4 \times 10^{-3}$ $M$) and indoleacetic acid ($2 \times 10^{-3}$ $M$) were allowed to react in 50 per cent ethanol in Warburg flasks, with shaking, in darkness and at a temperature of 20° C. The output of carbon dioxide and uptake of oxygen with time are shown in Fig. 2. From a similar mixture in a Warburg flask under similar conditions, samples were removed at intervals and tested for indoleacetic acid content by the Salkowski method (Tang and Bonner[2]); the change with time is shown in Fig. 2. It is clear that the presence of ferric ions induced decarboxylation and consequent destruction of almost all the indoleacetic acid with the uptake of an equal volume of oxygen, giving a coloured substance.

Manometric measurements and Salkowski tests on mixtures containing $2 \times 10^{-3}$ $M$ indoleacetic acid and $4 \times 10^{-3}$ $M$ cupric nitrate under the same conditions gave no measurable gas exchange, but 10 per cent break-down of indoleacetic acid occurred over $4\frac{1}{2}$ hr.

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## Effect of Fumigation and Moisture Content on the Seedling Growth of Cowpea (*Vigna unguiculata*)

It has been shown[1] that the fumigation of maize grain with a 1 : 1 mixture of ethylene dichloride and carbon tetrachloride adversely affects the growth of seedlings raised from the grain. Similar results have now been obtained from a study of the early growth of cowpeas raised from fumigated seed.

A supply of cowpea was obtained which had a moisture content of 12 per cent, and half was dried to a moisture content of 10 per cent by spreading out in a room with a low atmospheric humidity. Two 2-lb. jars were filled with seed at each moisture content, and one of each of these was fumigated with a 1 : 1 mixture of carbon tetrachloride and ethylene dichloride at a concentration of 20 cm.³ of total storage volume. All the jars were sealed and after two months they were opened and 30 seeds from each of the two treatments and two controls were taken and planted 10 per pot in 8-in. pots filled with garden soil. Eleven days after sowing, the plants which had grown were removed and their fresh weights determined (Table 1).

From a comparison of the results for the two control series it is evident that drying the seed to the lower moisture content had a retarding effect on early growth. Most plants grown from seed of 12 per cent moisture content were more than 2·0 gm. in weight, whereas most of those from seeds with a moisture content of 10 per cent weighed 1·1–1·4 gm. at the end of the experiment.

The effect of fumigation was particularly noticeable with seedlings arising from seeds with the higher moisture content; a quarter of the seedlings in this group weighed less than 0·2 gm. Plants grown from seeds with the lower

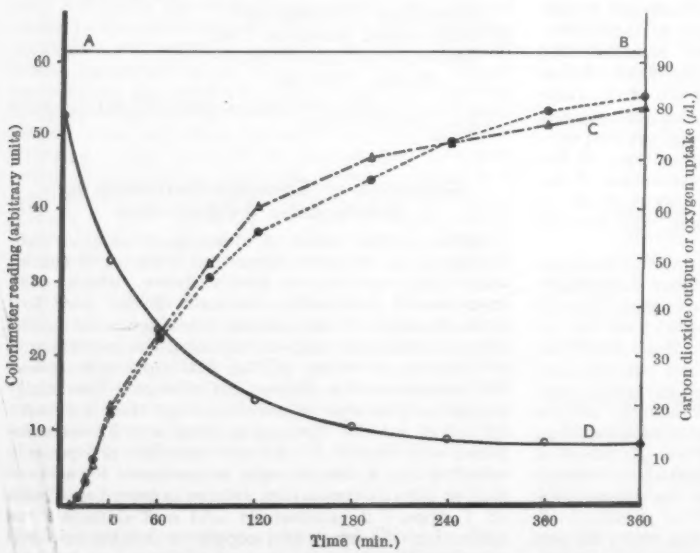


Fig. 2. *AB*, Theoretical output of carbon dioxide (μl.) for complete breakdown of 3-indoleacetic acid; *C*, 89 per cent breakdown of 3-indoleacetic acid, output of carbon dioxide (△) and oxygen uptake (●); *D*, colorimeter reading for 84 per cent breakdown of 3-indoleacetic acid

Table 1. Fresh Weights of Seedlings grown from Fumigated and Unfumigated Seed of Different Moisture Contents

| Fresh weight (gm.) | Number of plants | | | |
|---|---|---|---|---|
| | 10 per cent moisture | | 12 per cent moisture | |
| | Control | Treated | Control | Treated |
| 0·0–0·2 | — | 1 | 1 | 7 |
| 0·3–0·5 | 1 | 5 | 1 | 1 |
| 0·6–0·8 | 1 | 4 | 2 | 0 |
| 0·9–1·1 | 6 | 5 | 1 | 1 |
| 1·2–1·4 | 10 | 6 | 7 | 2 |
| 1·5–1·7 | 5 | 1 | 2 | 3 |
| 1·8–2·0 | 4 | 2 | 4 | 3 |
| > 2·1 | 3 | 4 | 12 | 10 |
| Total | 30 | 28 | 30 | 27 |

moisture content did not appear to suffer so drastically from fumigation though their general growth was retarded.

It seems likely from work still in progress that the retardation of growth in seedlings from seeds with the lower moisture content is only temporary and will not affect the ultimate yield. However, the severe retardation observed for about a quarter of the plants grown from the moister seeds that had been fumigated is likely to be permanent, the seedlings being deformed and only slowly, if ever, reaching maturity.

The above results stress the need for measuring growth and yield as well as germination when considering the effect of fumigants on stored seed to be used for planting.

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## An Age Effect on Seta Elongation in *Pellia epiphylla*

In a recent communication, Asprey *et al.*[1] report that spraying with indolylacetic acid and gibberellin effects elongation of the setæ of *Pellia epiphylla* in January, whereas under normal conditions this is delayed until late February or early March. We have obtained results which suggest that during the winter months a gradual change occurs, bringing setæ into a condition when they are capable of rapid elongation once the temperature is raised. In view of the results of Asprey *et al.*, this internal change may well be correlated with synthesis of growth hormones.

Table 1. Effects of Age, Rise in Temperature and Extra Light on Seta Elongation

Time (weeks) from collecting material until 50 per cent of the setae started to elongate

| Treatment | Date collected | | | | | |
|---|---|---|---|---|---|---|
| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. |
| 15° C., normal light | 20 | 14·5 | 8 | 5·5 | 2·5 | 0·5 |
| 15° C., normal light* | 21 | 14 | 9 | — | — | — |
| 15° C., normal light + 10 f.c. tungsten light for 16 hr. each day | — | 10 | 6·5 | 4·5 | 2 | 0·5 |
| 15° C., normal light + 10 f.c. tungsten light for 16 hr. each day* | 15 | 9·5 | 7 | — | — | — |

* Kept 2 weeks at 1° C. immediately after collection.

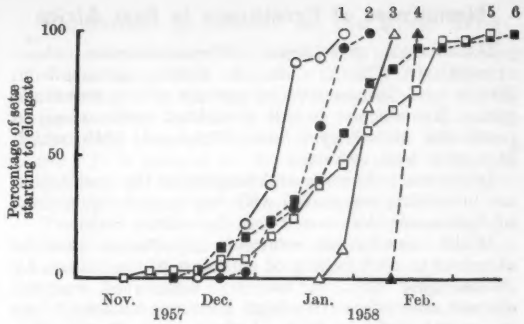


Fig. 1. Effect of age on the ability of setæ to elongate when transferred to 15° C. Material in the field showed no seta elongation until March 1958. Dates transferred: 1, November; 2, December; 3, January; 4, February; 5, September; 6, October

Fresh material of *Pellia epiphylla* was collected from a site near Southampton at intervals from mid-September 1957 to February 1958 and kept in a warm greenhouse (mean temperature 15° C., minimum 10° C.). The number of setæ elongating was counted at weekly intervals and the capsule contents also examined. Fig. 1 shows that rise in temperature promotes seta elongation in every case (material left in the field did not start to elongate until March 1958), but the most marked effect is that of age of the sporophyte. This is shown more clearly in Table 1, which records the lag period before 50 per cent of the setæ start to elongate. Two weeks cold treatment (1° C.) given immediately after material had been collected did not affect the results, but provision of extra light shortened the lag period slightly. It is tentatively suggested that during the winter there is a slow synthesis of growth hormones (or removal of a growth inhibitor), which is stimulated to some extent by a rise in temperature and extra light. The fact that the maximum length reached by setæ was considerably less in samples collected early in the season would also support this idea. It would be of particular interest to know if indolylacetic acid and gibberellin are effective in promoting seta elongation in material collected in the autumn.

Subsidiary observations were made on spore development, since it has been suggested that maturation of the spores is the stimulus for seta elongation. Under normal conditions the tetrads divide into spores at the end of November, but material collected in September and October before this change had occurred and kept at a warm temperature, had not formed spores by March 1958, when observations were discontinued. Despite immaturity of the spores seta elongation occurred (Table 1), and it is therefore highly improbable that there is a direct relationship between spore maturation and seta elongation. A similar conclusion was reached by Asprey *et al.* from their experiments. A further observation supporting this was that two weeks cold treatment was effective in stimulating tetrad division in material collected in October, but seta elongation was unaffected.

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## Nematoses of Pyrethrum in East Africa

Dalmatian pyrethrum (*Chrysanthemum cinerariaefolium*) (Trev.) Vis. is widely attacked in Kenya and Tanganyika by species of the nematode genus *Meloidogyne* Goeldi (root-knot nematodes), in particular *Meloidogyne hapla* Chitwood, 1949, which is a new host record.

Interveinal chlorosis and necrosis of the leaf lamina are invariably associated with heavy leaf populations of *Aphelenchoides ritzema-bosi* (Schwartz) Steiner.

While considerable economic importance must be attached to root galling of commercial pyrethrum by *Meloidogyne* spp., a recently discovered root-rot disease associated with high root populations of an apparently new species of the genus *Pratylenchus* Filipjev may prove of equal importance in pyrethrum farms at altitudes between 7,000 and 9,000 ft. This disease, although suspected in several areas of Kenya, was first found on a two-year-old planting at 8,500 ft. near Limuru, Kenya. Of 72 random samples of roots with surrounding soil, collected in groups of 24 at bi-monthly intervals from three adjacent terraces of very stunted plants, 57 were affected by a root-rot disease, with which *Pratylenchus* n.sp. was invariably associated. Heavy attacks of *M. hapla* were also present but not correlated with the symptoms of root-rot.

The first sign of this root-rot is the appearance of small patches of a brownish discoloration on the root epithelium. These lesions increase in area, darken and penetrate to the stele, girdling and eventually producing an almost completely blackened root. Eggs, larvæ and adults are found in affected tissue, specimens being recoverable even from the smallest lesions. Other nematodes and fungi are found in the later stages of the disease but not apparently in the early lesions.

Although *Pratylenchus* spp. have been reported in species of *Chrysanthemum* (Tourn.) L.[1–4] invasion and reproduction in the roots of *C. cinerariaefolium* by *Pratylenchus* n.sp. constitutes a new host record. A detailed description of the parasite will be published elsewhere.

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## Heavy Infestation by the Parasitic Copepod *Lernaeenicus* of Sprats in the River Crouch

Whitebait sprats in the estuary of the River Crouch collected in May 1957 were found to be heavily infested with copepod parasites. The fishes were collected by using a 12-ft. beam trawl with shrimp netting, several hauls being made between Burnham-on-Crouch and Holiwell Point, just inside the mouth of the River Crouch in Essex. Of the 140 sprats (*Culpea sprattus*) captured, 43 (31 per cent) were afterwards found to be parasitized by the copepod *Lernaeenicus*. The two British species of this genus, *L. sprattae* and *L. encrasicola*, were both present. It is a general rule that *L. sprattae* is fixed in the eye of the fish while *L. encrasicola* has its head buried in the tissues of the body, usually in the back, and the present sample was no exception to this rule. The sprats may be divided into the following categories:

97 sprats with no copepod parasites
32 sprats with one *L. sprattae* in one eye
2 sprats with two *L. sprattae* in one eye
7 sprats with one *L. encrasicola* in the back
1 sprat with two *L. encrasicola* in the back
1 sprat with one *L. sprattae* in an eye and one *L. encrasicola* in the back

*L. sprattae* is most easily distinguished from *L. encrasicola* by the moniliform appearance of the neck, as can be seen in Fig. 1. There is no doubt that the present infestation of more than 30 per cent of the fish is a severe one, but there are very few records in the literature which give a definite indication of the number of sprats parasitized in a sample. Leigh-Sharpe[1] gives 3 per cent infestation for two samples taken at Hole's Hole, near Plymouth, independently by himself and Dr. R. Gurney in 1934, and he quotes T. Scott and A. Scott's[2] earlier figure of 2·3 per cent at Plymouth in 1910. Among Gurney's manuscript papers now in the British Museum there is a note directing attention to the remarkable fact that his specimens of *Lernaeenicus* from Hole's Hole, from more than 1,000 fishes, collected on April 10, 1934, were young, not one of them being fully grown or bearing eggs, while Leigh-Sharpe's specimens from 970 sprats, collected from the same place in the spring of the same year, presumably a little later though the actual date is not known, were mature and bearing eggs. A rapid growth of the parasite is indicated, with presumably an adverse effect on the host.

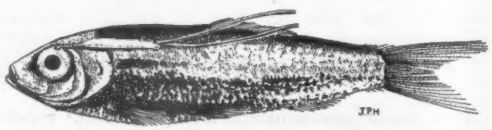


Fig. 1. A sprat about 5 cm. long with a parasite (*Lernaeenicus sprattae*) embedded in the eye. Note the hole in the eye, the moniliform shape of the neck and the two long strings of eggs which stream out from the hinder end of the cylindrical body of the parasite

In the rather overcrowded conditions of fish farms in hot countries, infestations of the fishes by the similar copepod *Lernaea* sometimes occur which are more severe than any known under natural conditions; Nakai[3] describes eels and loaches with the buccal cavity so crowded with parasites that food could not be swallowed. Very little, however, is known about the effect on fishes, under natural conditions, of copepod parasites of this type which live with the head buried in the tissues of the host, presumably feeding on blood and other fluid tissues. It was thought that with such a large sample of fish, both with and without parasites, it would be easy to detect signs of unhealthiness in the parasitized fishes, but this was not so, even statistically. The shape-index ($S$) was calculated for each fish using the formula $S = K \frac{\sqrt[3]{w}}{l}$ where $w$ is the weight in gm., $l$ the standard length in cm., and $K$ is a constant. For fishes of the same length, the greater the weight the greater the shape-index. Each of 138 fishes was

measured individually to the nearest mm. and weighed to the nearest 10 mgm., two of the original sample were discarded owing to damage, one of them parasitized. The value of $K$ used (5·14) is such that a normal fish has the shape-index of 1·0, in other words, of the 138 fishes measured, 69 had an index of less than 1·0 and 69 greater than 1·0. The shape-index of each fish is plotted against its length in Fig. 2. On the left side of the figure are the fishes without parasites and on the right, for comparison, are the smaller number with parasites. The pattern of distribution shown in this figure is substantially the same for both groups of fishes. Of the 42 parasitized fishes measured, 25 had a shape index greater than, and 17 less than, unity; and of the 96 healthy fishes 44 had an index greater than, and 52 less than, unity. This would indicate a beneficial effect of the parasite on the weight of the fish, but the difference is slight and probably not statistically significant.

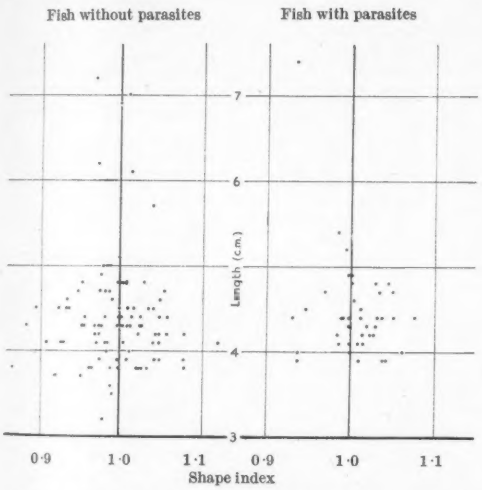


Fig. 2. Shape index and length distributions of parasitized and normal fishes

The lengths of the fishes shown in Fig. 2, varying from 3·2 to 7·4 cm. in standard length, fall within the size range given by Robertson[4] for samples of whitebait sprats from the Thames Estuary, which he considered to be mainly composed of 0-group fishes. The considerable size-range is probably a reflexion of the prolonged spawning season of sprat in the North Sea—March to August (maximum in June); and the few large fishes, one of which was parasitized, were probably spawned early in the season and were thus 1-group or close to it when caught. This conclusion, which is in conformity with Robertson's findings, was supported by an examination of the few scales present on two of the large sprats which appeared to be those of 1-group fishes.

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## Movement of Salmon on the River Erne

A graphic record of salmon (*Salmo salar*) ascending the fish pass at Cathaleen's Fall Hydro-Electric Generating Station has been kept for four fishing seasons. This station is one of two erected by the Electricity Supply Board, Ireland, on the River Erne. It is located at the toe of a dam across the river and has an installed capacity of 45,000 kW. and a gross head of approximately 100 ft.

The fish ladder extends from the power station tailrace over the dam into the head waters. The tailrace is tidal. The ladder is of the White submerged-orifice type similar to those developed and used by the North of Scotland Hydro-Electric Board at its Pitlochry and Clunie power stations. It has 73 pools with a difference in water-level of 1½ ft. between successive pools. Some of the bottom pools are, however, submerged except at low tide or when the turbines in the power station are not operating; some of the top pools are by-passed at low reservoir levels. Orientation of the pass is approximately east–west.

The counter is of the nylon-screen type developed by the Board and has as an accessory a recording voltmeter which shows on a chart the time of the passage of each fish through the counter.

A preliminary analysis of the results so far available indicates the following movements of salmon: (*a*) an almost complete cessation of activity during hours of darkness; (*b*) greatest activity between noon and dusk; (*c*) the number of fish travelling singly is small in comparison with the total count.

P. A. Jackson

Cathaleen's Fall Generating Station,
Ballyshannon,
Co. Donegal.
June 27.

## Pigmy Sperm Whale (*Kogia breviceps*) in Borneo

In recent years the Sarawak Museum has developed a system by which people along the west coast of Borneo report (if they have time) the occurrence of any beached cetacean. Partly by this means, and with the help of Malays and Dayaks, we have extended the local list from five to fourteen known forms in the past five years, advised and criticized by Dr. F. C. Fraser, of the British Museum (Natural History).

In 1956, and again in 1957, complete examples of the comparatively rare Bryde's whale (*Balaenoptera brydei*) were obtained in this way, and on February 19, 1958, we were able to recover from Buntal in south-west Sarawak, a perfect specimen of the very little-known pigmy sperm whale (*Kogia breviceps*). This miniature 10-ft. version of the sperm whale—the greatest of all the toothed cetaceans—has not previously been recorded from this part of the world. Of added interest was the presence of a well-developed embryo. A beautiful baby, of a battleship-grey, it is 14½ in. long. Two of seven previously recorded embryos are from European waters.

Photographs and measurements have been sent to the British Museum (Natural History) for confirmation of identification.

Tom Harrisson
George Jamuh

Sarawak Museum,
Borneo.

# FORTHCOMING EVENTS

## Wednesday, August 27—Wednesday, September 3

British Association for the Advancement of Science (at Glasgow).—Annual Meeting.

**Wednesday, August 27**

At 7.15 p.m.—Sir Alexander Fleck, F.R.S.: "Science and Business: a Balanced Partnership" (Presidential Address).

**Thursday, August 28**

At 10 a.m.—Prof. H. J. Emeléus, F.R.S.: "The Chemistry of the Transuranic Elements" (Presidential Address, Section B).

At 10 a.m.—Dr. A. S. Parkes, F.R.S.: "Some Biological Effects of Low Temperatures" (Presidential Address, Section D).

At 10 a.m.—Prof. R. S. Adamson: "The Cape as an Ancient African Flora" (Presidential Address, Section K).

At 10 a.m.—Dr. D. P. Cuthbertson: "Digestion in the Ruminant" (Presidential Address, Section M).

At 11.15 a.m.—Prof. H. M. Steven: "The Native Pinewoods of Scotland and their Significance for Current Forestry Practice" (Chairman's Address, Section K*).

At 11.30 a.m.—Prof. R. W. Bickford: "A Review of Some Problems of Colour Vision and Colour Blindness" (Presidential Address, Section J).

At 2.15 p.m.—The Rt. Hon. Lord Boyd Orr, F.R.S.: "The Cultural Value of Local Societies" (Presidential Address, Section X).

**Friday, August 29**

At 10 a.m.—Prof. E. Estyn Evans: "The Atlantic Ends of Europe" (Presidential Address, Section E).

At 10 a.m.—Prof. A. J. Brown: "Inflation and the British Economy" (Presidential Address, Section F).

At 10 a.m.—Prof. O. A. Saunders, F.R.S.: "Heat and the Engineer" (Presidential Address, Section G).

At 11.30 a.m.—Sir Willis Jackson, F.R.S.: "The Partnership between Industry and Education" (Presidential Address, Section L).

At 8 p.m.—Sir Christopher Hinton, F.R.S.: "Nuclear Power and the Engineer" (Evening Discourse).

**Sunday, August 31**

At 11 a.m. (in Glasgow Cathedral)—Religious Service. Preacher: The Reverend Dr. Nevile Davidson, Minister of Glasgow.

**Monday, September 1**

At 10 a.m.—Dr. T. E. Allibone, F.R.S.: "Some Aspects of Thermonuclear Power" (Presidential Address, Section A).

At 10 a.m.—Prof. L. R. Wager, F.R.S.: "Beneath the Earth's Crust" (Presidential Address, Section C).

At 10 a.m.—Dr. Iorwerth C. Peate: "The Study of Folk Life and Its Part in the Defence of Civilization" (Presidential Address, Section H).

At 10 a.m.—Dr. E. N. Willmer: "Some Aspects of Cellular Differentiation" (Presidential Address, Section I).

At 8 p.m.—Dr. C. F. A. Pantin, F.R.S.: "Living Machinery and the Electron Microscope" (Evening Discourse).

## Wednesday, August 27—Wednesday, September 3

The Combustion Institute, in collaboration with the Institute of Fuel (at the Royal Institution of Great Britain, 21 Albemarle Street, London, W.1, and at Oxford)—Seventh International Symposium on "Combustion".

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Assistant (with a degree in agriculture with special reference to animal husbandry or production), for investigations on carcase quality of beef—The Secretary, School of Agriculture, The University, Cambridge (September 8).

Junior Research Fellow in Geography—The Registrar, The University, Sheffield (September 13).

Lecturer/Senior Lecturer (preferably with a special interest in morphological, physiological or chemical cytology) in Histology and Embryology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 13).

Assistant Experimental Officer (with a degree or diploma in agriculture or botany and preferably a knowledge of potato varieties) in the Virus Diseases Section—The Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian (September 15).

Assistant Lecturer (with special qualifications in applied mathematics) in Mathematics—The Registrar, The University, Manchester 13 (September 15).

Lecturer in Pure Mathematics—The Registrar, The University, Hull (September 15).

Senior Lecturer or Lecturer in Physics at the University of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 22).

Assistant Lecturer in Botany—The Registrar, The University, Manchester 13 (September 30).

Chair of Logic and Metaphysics—The Secretary to the Curators of Patronage, The University, 4 Albyn Place, Edinburgh 2 (September 30).

Director (academically well qualified, of proven scientific leadership and administrative ability) of the Cawthron Institute, Nelson, New Zealand, to develop researches primarily into plant nutrition problems of horticulture and agriculture—The Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, New Zealand or the N.Z. High Commissioner, 415 Strand, London, W.C.2 (New Zealand, September 30).

Lecturer in Inorganic Chemistry at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

Research Officer (preferably with a good university honours degree in physics, or mathematics, with postgraduate research experience) in the Division of Meteorological Physics, C.S.I.R.O., Aspendale, Victoria, Australia, to participate in a programme of research into the micro-meteorological aspects of various agricultural problems with special emphasis on the study of evaporation from natural surfaces—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 420/127 (September 30).

Chair of Soil Science in the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 8).

Lecturer in Psychology at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer/Senior Lecturer in Pathology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Assistant Experimental Officer (with a degree in chemistry or agricultural chemistry), to carry out chemical analyses of soils and plants—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Assistant Lecturer (with an honours degree and interested in research work) in the Botany Section of the School of Pharmacy—The Secretary, Royal College of Science and Technology, Glasgow.

Head (with high academic qualifications in mathematics, teaching and research or industrial experience, and preferably specialized in statistics and/or numerical analysis) of the Department of Mathematics—The Principal, College of Technology, Queen Street South, Huddersfield.

Plant Pathologist (male, with a good honours degree in agriculture or natural science, at least one years postgraduate training in mycology and plant pathology, and preferably a knowledge of virus diseases) in the Department of Agriculture, Tanganyika, for field and laboratory work in the diagnosis and investigation of fungal and bacterial diseases of crop plants and the testing of control measures—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/08.

Principal Fisheries Research Officer (with a good honours degree in zoology and considerable postgraduate experience in fisheries research) with the Federation of Nigeria, to lead a small group of scientists and technicians in either sea fisheries research or inland fisheries and fish culture research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/14/03.

Research Assistant (with the B.Sc. (Special Chemistry) Degree of the University of London) in Chemistry—The Registrar, Brighton Technical College, Brighton, Sussex.

Senior Technician and other technical staff, for work upon steroid hormone assays in relation to gynaecology—The Director of the Endocrine Unit, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3.

Technician or Junior Technician in the Histopathology Department—The Director of Pathology, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3.

Tsetse Officers (male, under 30, with a good honours degree in biology) in Tanganyika, for tsetse surveys and subsequently to advise on anti-tsetse measures—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/022.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Universities Council for Adult Education. Report on the year 1956–1957. Pp. 27. (Bristol: W. E. Salt, Hon. Secretary and Treasurer, c/o The University, 1958.) [77

Scientific Film Association. Sixth Annual Report: A Report of the Council for the year ending March 31st, 1958. Pp. 12. (London: Scientific Film Association, 1958.) [77

Prime Numbers in Dynamic Geometry. By S. Ryzewski. Pp. 14. (Southampton: S. Ryzewski, 15 Landguard Road, 1958.) [77

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